



Appendix C

Technical Memorandum TM-34-6

CONNECTICUT RIVER WATERSHED 2003 BIOLOGICAL ASSESSMENT

BENTHIC MACROINVERTEBRATES

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INTRODUCTION

Biological monitoring is a useful, cost-effective method of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Barbour et al. 1999, Barbour et al. 1995). Surveying and assessing the status of these aquatic communities and the quality of their habitats are the principle tools of biomonitoring.

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2003 Connecticut River watershed assessments, aquatic benthic macroinvertebrate biomonitoring and habitat assessment were conducted to evaluate the biological health of selected portions of the watershed. A total of six benthic stations were sampled to investigate the effects of a variety of potential stressors on resident biological communities.

Collection and analysis of macroinvertebrate data provide information necessary for making aquatic life use-support determinations required by Section 305(b) of the Clean Water Act. All Connecticut River watershed biomonitoring stations were compared to a reference station (Amethyst Brook - station B0514) most representative of the "best attainable" (i.e., least-impacted) conditions in the watershed. The selection of the reference station to use for comparisons to a study site was based on comparability of stream morphology, flow regimes, and drainage area. Use of a watershed reference station is particularly useful in assessing nonpoint source pollution originating from multiple and/or unknown sources in a watershed (Hughes 1989). Both the quality and quantity of available habitat affect the structure and composition of resident biological communities. Effects of habitat features can be minimized by comparing collected data to reference stations with similar habitats (Barbour et al. 1999). Sampling highly similar habitats also reduces metric variability attributable to factors such as current speed and substrate type.

During "year 1" of its "5-year basin cycle", areas of concern within the Connecticut River watershed were defined more specifically through such processes as coordination with appropriate groups, assessing existing data, and conducting site visits. Following these activities, the 2003 biomonitoring plan was more closely focused and the study objectives better defined. The main objectives of the 2003 biomonitoring in the Connecticut River watershed were: (a) to determine the biological health of streams within the watershed by conducting assessments based on aquatic macroinvertebrate communities; and (b) to identify impaired stream segments so that efforts can be focused on developing remediation strategies. Specific tasks were:

1. Conduct benthic macroinvertebrate sampling and habitat assessments at locations throughout the Connecticut River watershed;
2. Based upon the benthic macroinvertebrate and habitat data, identify river segments within the watershed with potential impairments and pollution problems; and
3. Using the benthic macroinvertebrate community data, and supporting water chemistry (when available) and field/habitat data:
 - assess the types of water quality and/or water quantity problems that are present.
 - make recommendations for remedial actions or additional monitoring and assessment.
 - provide macroinvertebrate and habitat data to MassDEP/DWM's Environmental Monitoring and Assessment Program for assessments of aquatic life use and aesthetics use-support status required by Section 305(b) of the Federal Clean Water Act (CWA).
 - provide macroinvertebrate and habitat data for other informational needs of Massachusetts regulatory agencies, non-governmental organizations, and others.

Biomonitoring station locations, along with station identification numbers and sampling dates, are noted in Table 1. Sampling locations are also shown in Figure 1.

Table 1. List of benthic biomonitoring stations sampled during the 2003 Connecticut River watershed survey, including station identification number, mile point (distance from mouth), upstream drainage area, station description, and sampling date.

Station ID	Mile Point	Upstream Drainage Area (mi ²)	Connecticut River Watershed Benthic Station Description	Sampling Date
B0507	2.0	21	Stony Brook, ~30-meters upstream of powerlines, downstream from Route 116, South Hadley, MA	22 July 2003
B0508	0.5	14.6	Cushman Brook, ~300-meters upstream of Factory Hollow Pond, State Street, Amherst, MA	22 July 2003
B0509	3.6	54	Mill River (Northampton), West of Vernon Street, ~300-meters upstream of USGS gage 01171500, Northampton, MA	23 July 2003
B0510	9.3	35	Mill River (Hatfield), ~100-meters upstream of Mountain Drive, below the confluence of West Brook, Hatfield, MA	23 July 2003
B0514	0.8	9.3	Amethyst Brook, upstream of swale off end of Allen Mill Road, Amherst, MA	22 July 2003
B0515	2.5	31	Sawmill River, upstream at South Ferry Road, Montague, MA	22 July 2003

METHODS

MACROINVERTEBRATE SAMPLING

The macroinvertebrate sampling procedures employed during the 2003 Connecticut River Watershed biomonitoring survey are described in the *Standard Operating Procedures (Draft): Water Quality Monitoring in Streams Using Aquatic Macroinvertebrates* (Nuzzo 2002), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Barbour et al. 1999). The macroinvertebrate collection procedure utilized kick-sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms in a net as the current carries them downstream. Sampling activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2003a). Sampling was conducted by MassDEP/DWM biologists throughout a 100 m reach, in riffle/run areas with fast currents and rocky (boulder, cobble, pebble, and gravel) substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. Ten kicks in squares approximately 0.46 m x 0.46 m were composited for a total sample area of about 2 m². Samples were labeled and preserved in the field with denatured 95% ethanol, then brought to the MassDEP/DWM lab for further processing.

MACROINVERTEBRATE SAMPLE PROCESSING AND ANALYSIS

The macroinvertebrate sample processing and analysis procedures employed for the 2003 Connecticut River watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2002) and were conducted in accordance with the Quality Assurance Project Plan (QAPP) for benthic macroinvertebrate biomonitoring (MassDEP 2003a). Macroinvertebrate sample processing entailed random selection of specimens from the other materials in the sample until approximately 100 organisms ($\pm 10\%$) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity. Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin et al. 1989). Metric values for each station were scored based on comparability to the reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for a selected “least-impacted” reference station yields an impairment score for each site. The analysis separates sites into four categories: non-impacted, slightly impacted, moderately impacted, and severely impacted. Each impact category corresponds to a specific aquatic life use-support determination used in the CWA Section 305(b) water quality reporting process—non-impacted and slightly impacted communities are assessed as “support” in the 305(b) report; moderately impacted and severely impacted communities are assessed as “impaired.” A description of the *Aquatic Life* use designation is outlined in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 1996). Impacts to the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low taxa richness; or shifts in community composition relative to the reference station (Barbour et al. 1999). Those biological metrics calculated and used in the analysis of 2003 Connecticut River watershed macroinvertebrate data are listed and defined below [For a more detailed description of metrics used to evaluate benthos data, and the predicted response of these metrics to increasing perturbation, see Barbour et al. (1999)]:

1. Taxa Richness—a measure based on the number of taxa present. Generally increases with increasing water quality, habitat diversity, and habitat suitability. The lowest possible taxonomic level is assumed to be genus or species.
2. EPT Index—a count of the number of genera/species from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). As a group these are considered three of the more pollution sensitive aquatic insect orders. Therefore, the greater the contribution to total richness from these three orders, the healthier the community.
3. Biotic Index—Based on the Hilsenhoff Biotic Index (HBI), this is an index designed to produce a numerical value to indicate the level of organic pollution (Hilsenhoff 1987). Organisms have been assigned a value ranging from zero to ten based on their tolerance to organic pollution. Tolerance values (TV) currently used by MassDEP/DWM biologists were originally developed by Hilsenhoff and have since been supplemented by Bode et al. (1991) and Lenat (1993). A value of zero indicates the

taxon is highly intolerant of pollution and is likely to be found only in pollution-free waters. A value of ten indicates the taxon is tolerant of pollution and may be found in highly polluted waters. The number of organisms and the individually assigned values are used in a mathematical formula that describes the degree of organic pollution at the study site. The formula for calculating HBI is:

$$HBI = \frac{\sum x_i t_i}{n}$$

where

x_i = number of individuals within a taxon

t_i = tolerance value of a taxon

n = total number of organisms in the sample

4. **Ratio of EPT and Chironomidae Abundance**—The EPT and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Skewed populations having a disproportionate number of the generally tolerant Chironomidae (“midges”) relative to the more sensitive insect groups may indicate environmental stress.
5. **Percent Contribution Dominant Taxon**—is the percent contribution of the numerically dominant taxon (genus or species) to the total numbers of organisms. A community dominated by few species indicates environmental stress. Conversely, more balance among species indicates a healthier community.
6. **Ratio of Scraper and Filtering Collector Functional Feeding Groups**—This ratio reflects the community food base. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source (Barbour et al. 1999). Scrapers predominate when diatoms are the dominant food resource, and decrease in abundance when filamentous algae and mosses prevail. Filtering collectors thrive where filamentous algae and mosses are prevalent and where fine particulate organic matter (FPOM) levels are high.
7. **Community Similarity**—is a comparison of a study site community to a reference site community. Similarity is often based on indices that compare community composition. Most Community Similarity indices stress richness and/or richness and abundance. Generally speaking, communities with comparable habitat will become more dissimilar as stress increases. In the case of the Connecticut River watershed bioassessment, an index of macroinvertebrate community composition was calculated based on similarity (i.e., affinity) to the reference community, expressed as percent composition of the following organism groups: Oligochaeta, Ephemeroptera, Plecoptera, Coleoptera, Trichoptera, Chironomidae, and Other. This approach is based on a modification of the Percent Model Affinity (Novak and Bode 1992). The reference site affinity (RSA) metric is calculated as:

$$100 - (\sum \delta \times 0.5)$$

where δ is the difference between the reference percentage and the sample percentage for each taxonomic grouping. RSA percentages convert to RBPIII scores as follows: <35% receives 0 points; 2 points in the range from 35 to 49%; 4 points for 50 to 64%; and 6 points for $\geq 65\%$.

HABITAT ASSESSMENT

An evaluation of physical habitat quality is critical to any assessment of ecological integrity (Karr et al. 1986, Barbour et al. 1999). Habitat assessment supports understanding of the relationship between physical habitat quality and biological conditions, identifies obvious constraints on the attainable potential of a site, assists in the selection of appropriate sampling stations, and provides basic information for interpreting biosurvey results (US EPA 1995). Before leaving the sampling reach during the 2003 Connecticut River watershed macroinvertebrate biosurveys, habitat qualities were scored, and assessed, using a modification of the evaluation procedure in Barbour et al. (1999). The matrix used to assess habitat quality is based on key physical characteristics of the water body and related streamside features. Most parameters evaluated are instream physical attributes often related to overall land-use and are potential

sources of limitation to the aquatic biota (Barbour et al. 1999). The ten habitat parameters are as follow: instream cover, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left (when facing downstream) bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to a reference station to provide a final habitat ranking.

QUALITY CONTROL

Field and laboratory Quality Control (QC) activities were conducted in accordance with the Quality Assurance Project Plan (QAPP) for biomonitoring and habitat assessment (MassDEP 2003a). Quality Control procedures are further detailed in the standard operating procedures (Nuzzo 2002).

FIELD SAMPLING QUALITY CONTROL

Field Sampling QC entails: 1) Pre- and post-sampling rinses, inspection of, and picking of nets, sieves, and pans to prevent organisms collected from one station to be transferred to samples taken elsewhere. 2) On-site preservation of benthos sample in 95% ethanol to ensure proper preservation, and 3) collection of a duplicate sample at one in ten biomonitoring stations. A duplicate is collected as a “side by side” (where different assessment results are not expected due to the apparent absence of additional stressors) to each of the 10 kicks making up the “original” sample. A duplicate sample is composited in a similar manner to the original sample, yet, is preserved in a separate sample bottle marked “duplicate” and with all other information regarding station location remaining the same. Duplicate samples are used for the calculation of Precision of the benthos data.

FIELD ANALYTICAL QUALITY CONTROL

Habitat analysis QC entails multiple observers (at least both DWM benthic biologists, and often a third person) performing the Habitat Assessment at each macroinvertebrate biomonitoring station. A standardized Habitat Assessment Field Scoring Sheet is completed at all biomonitoring stations. Disagreement in habitat parameter scoring is discussed and resolved before the Habitat Assessment can be considered complete.

FIXED LABORATORY QUALITY CONTROL

Fixed Laboratory QC entails the following: 1) Taxonomy bench sheets are examined by a reviewer (the DWM biologist not responsible for the initial taxonomic identifications) for errors in transcription from bench notebook, count totals, and spelling. All bench sheets are examined, and detected errors are brought to the taxonomist's attention, discussed, and corrected. 2) Taxonomic duplication, in which “spot checks” are performed by a reviewer (the DWM biologist not responsible for the initial taxonomic identifications) on taxonomy, are performed at the reviewer's discretion. In general, all taxa that are rarely encountered in routine benthos samples, or taxa that the primary taxonomist may be less than optimally proficient at identifying, are checked. Spot checks are performed for all stations. Specimens may be sent to authorities for particular taxonomic groups. 3) Data reduction and analysis, including biological metric scoring (metric values are calculated through queries run in the DWM Benthic Macroinvertebrate Database), comparisons to reference station metrics, and impairment designations, are checked by a reviewer (the DWM biologist not responsible for performing the initial taxonomy and data analysis) for all benthos data at all stations. Detected errors are brought to the original taxonomist's attention and resolved. 4) Precision, a measure of mutual agreement among individual measurements or enumerated values of the same property of a sample and usually expressed as a standard deviation in absolute or relative terms, is compared using raw benthos data and metric values. If metric values and resulting scoring are significantly different (i.e., beyond an acceptable Relative Percent Difference) between the original and duplicate samples, the investigators will attempt to determine the cause of the discrepancy. Guidance regarding the calculation of Precision, including Relative Percent Difference (RPD) calculations and recommendations, can be found in US EPA (1995) and Barbour et al. (1999).

BASIN DESCRIPTION

The Connecticut River is the longest river in New England (USFWS 2006). It flows 405 miles from the Canadian border to Long Island Sound, and occupies a watershed area of 11,250 square miles (Kennedy and Weinstein 2000). In Massachusetts the Connecticut River watershed is, "located in Franklin, Hampshire, and Hampden Counties of west-central Massachusetts, and contains all or part of 46 cities and towns, including the cities of Holyoke, Chicopee, Westfield, Springfield, and Northampton. The elevation of the valley floor ranges from about 40 ft, where the Connecticut River crosses into Connecticut, to about 330 ft, except for long ridges of volcanic rock that reach altitudes of 600 to almost 1,000 ft. Elevations in the upland areas of the basin are as much as 1,500 ft." (USGS 2006a).

The mainstem of the Connecticut River within Massachusetts runs 67-miles from the VT / NH border to the CT border. Along this course, the Connecticut River receives the waters from the Millers, Deerfield, Chicopee and Westfield rivers. While these rivers are tributaries of the Connecticut, each of them is treated by MassDEP as a separate watershed for monitoring, assessment and other water quality management activities. The influence of these four major rivers is not inconsequential. Their combined discharge has a significant influence on flows within the Connecticut River (Mitchell 2006). The in-state watershed area of the Connecticut River watershed is 670 square-miles (Kennedy and Weinstein 2000) exclusive of the four major tributaries. The watershed areas of the four major tributaries are:

Millers River:	310 square-miles (Massachusetts portion only) (total area = 392 square-miles)
Deerfield River:	347 square-miles (Massachusetts portion only) (total area = 665 square-miles)
Chicopee River:	723 square-miles (entire watershed lays within Massachusetts)
Westfield River:	517 square-miles (Massachusetts portion only) (total area = 537 square-miles).

If the above watersheds were included with the Massachusetts portion of the Connecticut River Watershed, then the Connecticut River watershed would be 1,897 square-miles (Massachusetts portions only). This is roughly 18% of the entire area of Massachusetts.

According to the USGS streamflow within the Connecticut River Watershed was "Normal" during the time of biological sample collection (USGS 2006b).

RESULTS AND DISCUSSION

B0514 - Amethyst Brook

Mile point 0.8, Upstream of swale off end of Allen Mill Road, Amherst, MA

Habitat

Amethyst Brook is a "Class B" water (MassDEP 1996), and has never been assessed by the DWM. The brook begins at the confluence of Buffum and Harris brooks, in the Town of Pelham, MA. From this point, Amethyst Brook flows through a rather high-gradient reach within a narrow valley. Aside from a solitary road crossing (North Valley Road in Pelham), the abutting landuse is primarily forested. The brook then enters a small impoundment (one-mile from the Buffum Brook / Harris Brook confluence). The high-gradient nature of the stream continues upon leaving this impoundment, and Amethyst Brook enters B0514 0.4-miles from the upstream impoundment.

The within-reach habitat conditions were quite good (157 / 200)(Table A3). This score ranks B0514 third of the six stations examined. B0514 scored "marginal" in only one area – "Velocity / Depth Combinations" (10 / 20). This was due to the lack of any deep habitats. Indeed, the riffles were estimated at 0.1 meters deep, the runs at 0.2 meters deep, and the pools at 0.3 meters deep. However, this may be the natural state of the brook, as the water filled much of the available bed, and resulted in optimal Channel Flow

Status. Instream cover was assessed as “suboptimal” (12 / 20) due to few pools and a lack of stable refugia for fish, although the substrate was dominated by cobble (80%).

The brook, within this reach, is bordered by heavily used trails on both sides of the channel – and appears to be favored by dog-walkers. On the right bank, the trails run through a forested area. On the left bank, the trails run between the brook and residential land. The left bank vegetative protection score was 8 / 10 (suboptimal). This is due to the presence of residences and lawns along the left bank. The Riparian Vegetative Zone Width scored “suboptimal” (7 / 10) for both banks. The primary detractor was from the heavily used trails. The Bank Stability along the right bank also scored sub-optimally (8 / 10). There were extensive areas of “cut-bank” erosion along the right bank.

Amethyst Brook had extensive canopy cover (95%). Trees along both banks provided the shade. The types of trees observed included: Hemlock (*Tsuga canadensis*), Hornbeam (*Carpinus caroliniana*), Red Oak (*Quercus rubra*), Yellow Birch (*Betula lutea*), White Pine (*Pinus strobus*), Striped Maple (*Acer pensylvanicum*), Ash (*Fraxinus* sp.), White Oak (*Quercus alba*), and Elm (*Ulmus* sp.). Aquatic vegetation covered 5% of the available habitat and consisted entirely of mosses. There was no algae coverage within the reach.

Benthos

The collected benthos was dominated by the Filtering - Collectors (28%) and the Shredders (27%) functional feeding groups. B0514 had the lowest (best) Biotic Index score (3.48) of all stations examined. B0514 also had the lowest percent dominant taxa (14%), and the second highest taxa richness. The dominant taxon collected was Leuctra sp., a highly sensitive stonefly. The combination of these conditions makes Amethyst Brook a very satisfactory reference condition for wadeable streams within the Connecticut River Basin.

B0507 – Stony Brook

Mile point 2.0, approximately 30-meters upstream of powerlines, downstream from Route 116, South Hadley, MA

Habitat

Stony Brook – within this segment – is classified as Class B water as defined in the Massachusetts Surface Water Quality Standards (MassDEP 1996). The watershed contributing to B0507 is 21 mi². Stony Brook begins at the confluence of two unnamed, first-order streams east of Chicopee Road in Granby. It then passes through the Westover Municipal Golf Course in Ludlow. From here, it passes into Chicopee and Westover Metropolitan Airport. Stony Brook then flows north-northeast, back into Granby, and then into South Hadley. In South Hadley (both near and on the Mount Holyoke College campus) Stony Brook is impounded into Upper Pond and Lower Pond. Stony Brook flows out of these ponds and makes its way generally southward. The approximately 450-meters immediately upstream of Benthic Station B0507 finds Stony Brook paralleling Route 116. This stream reach is rather high-gradient, and Stony Brook flows under an old mill building, and is crossed by several small bridges that access commercial properties along Route 116. There is very little shading or canopy cover in the stream reach along Route 116.

The immediate habitat conditions within B0507 were deemed to be the highest of all stations examined during the 2003 Connecticut River Watershed Benthic Survey (160 / 200), including the regional reference station B0514. (Table A3). The Riparian Vegetative Zone Width (both left and right banks) and Riparian Bank Protection (both left and right banks) scored high. This is due, in part, to the lack of human activity within the sampled reach. Many rose bushes and stinging nettles were found along both banks. This condition dissuades people from accessing this reach. While open upstream the canopy cover at the sampling site was estimated at 80% and shaded the entire vicinity of the station. The riparian trees included Catalpa (*Catalpa speciosa*), Silver Maple (*Acer saccharinum*), Ash (*Fraxinus* sp.), Red Maple (*Acer rubrum*), and Elm (*Ulmus* sp.).

The sampled reach contained extensive riffles, and the Channel Flow Status was rated as optimal. The riffle depths were estimated at 0.2 meters deep, the runs at 0.4 meters deep, and the solitary pool (at the top of the reach) at 0.6 meters deep. Cobble dominated the inorganic substrates (80%), and detritus (CPOM – Coarse Particulate Organic Matter = >1mm) dominated the organic substrates (90%). The epifaunal substrate was optimal (17 / 20) for benthic macroinvertebrates due to the extensive areas of riffles, but there was poor (7 / 20) instream cover for fish due to the lack of pools and refugia. The within-reach algae coverage was estimated at 2%. Observed algae included both green filamentous and brown thin-film types. All algae were observed to be in the riffle zones. There were no aquatic plants observed within the sampled reach.

Benthos

The B0507 sample from Stony Brook was 76% comparable to the reference sample (Amethyst Brook, Amherst, MA), resulting in an assessment of “slightly impacted”. The benthic community was dominated by filter-collectors from the families Hydropsychidae and Philopotamidae. The upstream presence of impoundments (including Upper Pond and Lower Pond) augments the conditions favorable for the propagation of each of these families (Mackay and Waters 1986, Whiles and Dodds 2002). The dominance of filter – collectors alludes to an increase in nutrients and/or FPOM (Fine Particulate Organic Matter = <1mm). Although CPOM was the dominant organic substrate component observed within this reach, it is possible that, due to the stream velocities, FPOM was not being deposited within this reach.

The macroinvertebrate assemblage from Stony Brook had the highest (worst) Biotic Index score (5.05) and the lowest Taxa Richness (23) of all six Connecticut benthic stations examined during the 2003 Connecticut Benthic Survey. The elevated biotic index score indicates that the benthic community is dominated by species tolerant of eutrophication and/or organic pollution. The lower species diversity points towards a community with somewhat reduced health and function. Based on the high habitat score for this station, it is likely that the impact is due to water quality conditions.

B0508 – Cushman Brook

Mile point 0.5, approximately 300-meters upstream of Factory Hollow Pond, State Street, Amherst, MA

Habitat

Cushman Brook, a Class B water (MassDEP 1996), has never been assessed by MassDEP. Cushman Brook begins at the outfall of Atkins Reservoir (a drinking water supply for the Town of Amherst) in Shutesbury, MA. It flows through a narrow valley, paralleling East Leverett Road for 1.25 miles. Cushman Brook then flows under the road, and enters the Mill River conservation area. This conservation area contains trails that both parallel and cross Cushman Brook. The trails appeared to be well maintained, and not causing any instream habitat degradation. The 2003 benthic sample was collected from within this area.

The total habitat score for Cushman Brook was 154 / 200 (Table A3). This score ranks Cushman Brook fourth among the 6 stations examined during the 2003 Connecticut River Benthic Survey. Both banks were steep and only marginally stable – making them prone to erosion. Fallen trees were observed along the left bank. The Velocity-Depth Combinations parameter was reduced (10 / 20), and the sediment deposition was increased. The increase in sediment deposition may be responsible for the reduction in the number and size of the riffle areas, as well as an increase in the embeddedness of the substrates. Sediment deposition may be a natural occurrence. There is a gravel pit across State Street from this benthic station, and similar gravel rich soils most likely exist within the sampled stream reach. Nonetheless, the above-mentioned conditions reduced the overall habitat score.

Canopy cover was estimated to be 80%, providing adequate shading to the stream. The trees providing this cover included: Hemlock (*Tsuga canadensis*), Yellow Birch (*Betula lutea*), Hornbeam (*Carpinus caroliniana*), Striped Maple (*Acer pennsylvanicum*), Sycamore (*Platanus occidentalis*), Red Oak (*Quercus rubra*), and Sugar Maple (*Acer saccharum*). The Channel Flow Status was optimal (18 / 20). The riffle depths were estimated at 0.2 meters. Run depth was not recorded, and there were no pools (> 0.5

meters) within the sampled reach. Even though there were no deep (> 0.5 meters) habitats within the sampling reach, both the Instream Cover, and Epifaunal Substrate habitat measures scored in the “optimal” range. There was a good assortment of snags, logs and other refugia for fish, as well as a good variety of velocities flowing through the riffle zones. Cobble dominated the inorganic portion of the substrates within the sampled reach (80%), and CPOM dominated the organic fraction. Algal coverage was less than 5% throughout the reach, and was represented by green, thin-film algae.

Benthos

The total metric score for Cushman Brook is 86% comparable to the reference station (Amethyst Brook) in terms of community structure, resulting in an assessment of “non-impacted” (Table A2). The functional feeding groups (FFG) were well represented, with the exception of Scrapers (6% of the collected benthics). The low number of Scrapers collected may be related to the reduced algal coverage (especially thin-film periphyton) within the reach. The Gathering – Collector functional feeding group were the most dominant FFG (30%), but other FFGs were also well represented: Filter – Collectors (25%), Predators (13%), and Shredders (26%). The Gathering – Collectors were (with the exception of the mayfly genus *Paraleptophlebia* sp.) dominated by Chironomidae (78%). The Biotic Index for Cushman Brook was 3.86 – the second best score of all stations examined. This low Biotic Index points towards a community with good representation by intolerant species. The Cushman Brook benthic community had a Taxa Richness of 28. This ranks Cushman Brook as fourth of the six stations sampled in terms of richness.

B0509 – Mill River (Northampton)

Mile Point 3.6, west of Vernon Street, approximately 300-meters upstream of USGS gage 01171500, Northampton, MA

Habitat

The Mill River – Northampton (within this segment) is classified as Class B water (MassDEP 1996). The watershed contributing to B0509 is 54 mi². The Mill River – Northampton begins in the Town of Williamsburg at the confluence of the East and West Branches of the Mill River. The river flows 8.5 miles from this confluence to B0509. Along its way, it flows through many industrial revolution era impoundments, and heavily developed residential areas – including the city of Northampton. Station B0509 was located within a city-operated park (off of Burts Pit Road – locally known as “The Fields”). This park consists of an array of trails through old farmland. The overall habitat score for within reach conditions was 149 / 200 (Table A3). The bank stability of the right bank was marginal (4 / 10). This stands in contrast to the left bank that received a score of 10 / 10 for bank stability. The high scoring left bank contained a 2 meter high, concrete retaining wall that ran approximately 60-meters along the left bank from the top of the reach. This wall greatly affected flow conditions and bank conditions along the opposite bank. The wall forces the water towards the right bank. As a result, the right bank consisted of deposits of cobble, gravel and sand – with very little herbaceous cover. Also, heavy foot-traffic has further removed vegetation from the right bank. The foot traffic and deposition of coarse substrates on the right bank also reduced the bank vegetative protection score to a marginal level (4 / 10). The retaining wall on the left bank, and the trail atop the wall, reduced the bank vegetative protection score to a suboptimal level (7 / 10). The retaining wall also represents an alteration to natural channel morphology. As a result, the channel alteration score was observed to be suboptimal (13 / 20). Also, the riparian vegetative zone width scores (for both banks) were reduced. The effects of the retaining wall and the trail along the left bank reduced the riparian vegetative zone width score to suboptimal (8 / 10). The deposited gravel and foot traffic reduced the right bank riparian vegetative zone width score to marginal (4 / 10).

While the above habitat parameters diminished the overall habitat score, there were several habitat measures that scored well. The Channel Flow Status was optimal (17 / 20). The depth at the riffles was 0.3 meters. The depth at the runs was 1 meter, and the depth at the pools was 1.5 meters. Cobble dominated the inorganic portion of the instream substrates (50%). CPOM dominated the organic component of the instream substrates (95%). Algae coverage was estimated at 90%. Green, thin-film algae represented the observed type of algae and it was attached to rocks in both the pools and riffles. Canopy cover to the stream was estimated at 50%. The trees providing the shade included Red Oak

(*Quercus rubra*), Sycamore (*Platanus occidentalis*), Grey Birch (*Betula populifolia*), Red Maple (*Acer rubrum*), Ash (*Fraxinus* sp.), Elm (*Ulmus* sp.), Hornbeam (*Carpinus* sp.), White Pine (*Pinus strobus*), and Cottonwood (*Populus* sp.).

Benthos

The total metric score for B0509 is 81% comparable to the reference condition (Amethyst Brook, Amherst, MA) in terms of metric performance, resulting in an assessment of “slightly impacted” (Table A2). The functional feeding groups from B0509 were dominated by Scrapers (34%), and Filtering – Collectors (33%). The high percentage of Scrapers is to be expected given the extensive algal coverage. However, no single taxon accounted for more than 10% of the entire sample. This reduced percent dominant taxa denotes diversity among the taxa collected. The percent dominant taxa score at B0509 was the lowest (best) of all 6 stations examined in the Connecticut Watershed. There were 30 different taxa collected at B0509 which was the third highest of all six stations examined. The Biotic Index score for B0509 was the second highest (worst) of all six stations (4.98). This high score alludes to a community populated by taxa tolerant of eutrophication and organic pollution.

B0510 – Mill River (Hatfield)

Mile Point 9.3, upstream of Mountain Drive, below the confluence with West Brook, Hatfield, MA

Habitat

Mill River – Hatfield is classified as Class B water (MassDEP 1996). The Mill River – Hatfield watershed (serving B0510) is 35 mi². The river begins on the northeast slope of Fisher Hill in Conway, MA. The stream is very high-gradient, and flows over a bedrock, boulder, and cobble bed as it parallels Route 116. This portion of the watershed is heavily forested, with many conifers. Just as the stream enters the Town of Deerfield, the nature of the stream changes dramatically. Immediately below a “blown-out” dam, the stream enters the Connecticut River valley floor. Here, the stream becomes a low-gradient, meandering stream. It flows through fields and pastures, and loses much of its shading. In the Town of Whatley, the sandy soils allow for extensive meanders, and, during the summer months, portions of the stream have been known to dry up. After receiving the flows from Bloody Brook, Roaring Brook, and Great Swamp, the Mill River - Hatfield begins to parallel Route 91. The Mill River – Hatfield then enters the Town of Hatfield. The benthic station B0510 is located near the Hatfield / Whatley border.

The overall habitat score for B0510 was 158 / 200 (second only to the Stony Brook station B0507)(Table A3). Four of the 13 habitat measures scored below the optimal range. Channel Alteration scored sub-optimally (14 / 20) due to the boulders placed along the left bank to stabilize Route 91. The Left Bank Riparian Vegetative Zone Width score also received a designation of “suboptimal” (8/10). This is also due to the highway stabilization. The Sediment Deposition score was “suboptimal” (13 / 20) due to gravel deposits within the stream reach. These gravel deposits may be emanating from West Brook, which enters the Mill River – Hatfield immediately upstream of this reach. Channel Flow Status received a “marginal” score (9 / 20). Many of the substrates (primarily gravel) were left exposed. This condition may be due to water withdrawals from Roaring Brook by the Town of South Deerfield, or ground water recharge. All other habitat measures scored within the optimal range.

Although the Channel Flow Status was found to be suboptimal, the instream depths were adequate. Riffle zones were noted to be 0.3 meters deep, as were the run areas. The pools were deeper at 0.6 meters. The stream had a canopy coverage estimated at 50%. Thin lines of trees populated both banks. These included, Cottonwood (*Populus* sp.), Ash (*Fraxinus* sp.), Sugar Maple (*Acer saccharinum*), Sycamore (*Platanus occidentalis*), Elm (*Ulmus* sp.), and Dogwood (*Cornus florida*). Behind the trees, on the right bank was an area of field and behind the trees on the left bank was Route 91.

The instream habitat contained a large riffle zone - one of the last riffle zones available (not associated with a dam) before the river enters the Connecticut River. Cobble was the dominant inorganic portion of the substrates (65%), and CPOM was the dominant organic portion (100%). Algae coverage was estimated at 65%. Observed algae types included green filamentous and green mats. Both types were

attached to rocky substrates and found in both pools and riffles. Aquatic macrophyte coverage was also extensive, with 40% coverage noted within the reach.

Benthos

The B0510 total metric score is 71% comparable to the reference station (Amethyst Brook, Amherst, MA). This condition results in an assessment of “slightly impacted” (Table A2). All functional feeding groups were well represented, with the most even distribution of all stations examined. The dominant functional feeding group was Scrapers (36%). The dominant family within this group was Chironomidae (55%). The presence of many members of this family is considered to be a sign of reduced water quality. However, the four genera of Chironomidae collected had tolerance values of either five or six. These tolerance values classify the collected genera as mid-to-slightly tolerant. The Biotic Index score for B0510 was 4.70. While tolerance values are prescribed as a measure of a macroinvertebrates ability to tolerate eutrophication and organic pollution, the presence of tolerant taxa are to be expected from within a low-gradient stream, downstream of an extensive wetland. Mill River – Hatfield had the second lowest Taxa Richness (24). This reduced diversity points towards a community that may be structurally and functionally compromised. The high habitat evaluation, dense algal and macrophyte coverage, and lowest total metric score of all stations, points towards a community that reflects water quality limitations – likely related to nutrient loading.

B0515 – Sawmill River

Mile Point 2.5, upstream at South Ferry Road, Montague, MA

Habitat

The Sawmill River begins at the outfall of Lake Wyola in Shutesbury, MA. The river flows through a high-gradient valley of sparse residential development in the towns of Leverett and Montague. At 6.2 miles from Lake Wyola, the Sawmill River passes under Route 63 in Montague. The gradient downstream from this bridge to B0515 is not as high as it is upstream of Route 63. Here, the stream enters the Connecticut River valley floor. The Sawmill River begins to meander through an area of pastures and the thickly settled village of Montague. The river then passes down a bedrock falls that was once the site of an industrial revolution-era dam. This is the last large drop the river takes before it enters the Connecticut River. B0515 is located 0.8 miles from the bedrock falls, and approximately 10 miles from Lake Wyola.

The within-reach habitat conditions at B0515 were deemed to be the worst of all six stations examined (137 / 200)(Table A3). The reductions in the habitat score are primarily due to abutting agricultural practices. The reach flows through an area of pasture that contains cows. These cows have direct access to the stream and have worn paths to, and through, the stream. This has caused degradation of the vegetation on both banks. The reduced Bank Vegetative Protection score for both banks exemplifies the condition of obvious disruption. The right bank received a score of 4 / 10, and the left bank received a score of 5 / 10. Most of the herbaceous plants that are preferentially consumed by ruminants (such as cows) were not present. There is a very limited understory beneath the thin rows of trees along each bank. Much of the understory consisted of rose bushes (*Rosa* sp.). The Riparian Vegetative Zone Width score was also reduced on both banks. The left bank received a score of 3 / 10. This is a “marginal” rating, with the riparian zone being reduced to between 6 – 12 meters. The left bank received a score of 2 / 10. This is a “poor” rating with the riparian zone being reduced to less than 6 meters. The reduction in score is due to the removal of trees to create pastureland, and the impact that grazing animals have had on the native vegetation.

The Bank Stability along the right bank was rated as “marginal” (4 / 10), with “cut-bank” erosion being quite obvious. This may be a natural occurrence as the reach was within the Connecticut River valley floor. Here, the soils are much more sandy, and prone to erosion. Sediment Deposition was rated as suboptimal with some new increases in bar formation. This, also, may be a natural occurrence due to the sandy nature of the localized soils. The Instream Cover available to aquatic biota was marginal (8 / 20). Only 10-30% of the area had a stable habitat and the substrates (dominated by cobble – 80%) were often disturbed.

Channel Flow Status scored in the optimal range, with water reaching the base of both banks and minimal amounts of substrates exposed. The Velocity-Depth combinations were also optimal with all four patterns (shallow-fast, shallow-slow, deep-fast, deep-slow) being represented. The depths of the instream habitats within this 5-meter wide river were adequate. The riffles were estimated at 0.2 meters deep. The runs were 0.3 meters deep, and the pools were 0.4 meters deep.

The canopy cover was estimated at 70%. The trees providing this shade included: Sugar Maple (*Acer saccharum*), Elm (*Ulmus* sp.), Willow (*Salix* sp.), and Hornbeam (*Carpinus caroliniana*). No algae, or aquatic macrophytes were observed within this reach.

Benthos

The benthic community collected at B0515 did not reflect the perturbation observed in the within-reach habitat. The community appeared to be in good health. The total metric score for B0515 is 90% comparable to the reference condition (B0514 – Amethyst Brook)(Table A2) resulting in an assessment of “non-impacted”. The Scraper functional feeding group (34%) dominated the collected benthic community from B0515. In turn, the family Elmidae dominated the Scraper functional feeding group (69%). This family is known to feed on attached algae and diatoms. The dominant taxon within the family Elmidae was *Optioservus* sp. This taxon is fairly sensitive to pollution, and requires high concentrations of dissolved oxygen. The Biotic Index score was 4.31. This score ranks B0515 third in comparison to the five other stations examined. When compared with other stations assessed, the collected benthic community from B0515 exhibited the highest number of different taxa (Taxa Richness = 35). This condition points towards a diverse community with good health and function. The EPT Index score (16) was also the best of all stations examined in the Connecticut Basin.

SUMMARY AND RECOMMENDATIONS

Benthic monitoring stations within the Connecticut River Basin included wadeable streams that were monitored employing DWM kick-net methodologies (Nuzzo 2002). The reference station (B0514 – Amethyst Brook) was chosen based on the reduced development within the contributing watershed, the lack of significant water withdrawals upstream of B0514, and high scoring metric values.

Cushman Brook (B0508) was initially considered a potential reference station. Contributing to B0508 is a Class A drinking water supply (Atkins Reservoir), and the watershed supplying that reservoir is well protected. However, the withdrawal of water could potentially affect the instream community, and there is significant agricultural and residential activity below the reservoir, and along East Leverett and Market Hill Roads. These two roads parallel the course of Cushman Brook, on either side of the stream.

Overall habitat scores (with the exception of B0515 – Sawmill River) were fairly comparable. They ranged from 149 / 200 at B0509 (Mill River – Northampton) to 160 / 200 at B0507 (Stony Brook). This is quite a tight range (11 points). The Sawmill River (B0515) stands out with the lowest habitat score (137 / 200).

The biomonitoring station used for a reference condition in the Connecticut River Watershed was Amethyst Brook (B0514). This station supports the diverse and well-balanced aquatic community expected in a “least-impacted” stream system. Including the reference station, three Connecticut River watershed biomonitoring study stations were found to be non-impacted. The other three stations were considered slightly impacted relative to reference conditions. Impacts to resident biota in this watershed were generally a result of habitat degradation and/or nonpoint source-related water quality impairment, with potential point source effects, observed as well.

Overall, collected benthic communities revealed “Non-Impacted” conditions at the following stations:

Stations with Non-Impacted Benthic Communities

Cushman Brook	B0508
Amethyst Brook	B0514 (Reference Station)
Sawmill River	B0515

Benthic communities revealed “slightly impacted” conditions at the following stations:

Stations with Slightly Impacted Benthic Communities

Stony Brook	B0507
Mill River – Northampton	B0509
Mill River – Hatfield	B0510

The schematic below (Figure 2) is based on a proposed conceptual model that predicts the response of aquatic communities to increasing human disturbance. It incorporates both the biological condition impact categories outlined in the RBPIII biological assessment methodology currently used by MassDEP and the Tiered Aquatic Life Use (TALU) conceptual model developed by the US EPA and refined by various state environmental agencies (US EPA 2003). The model summarizes the main attributes of an aquatic community (in this case the benthic macroinvertebrate community **only**) that can be expected at each level of the biological condition category, and how these metric-based bioassessments can then be used to make aquatic life use determinations as part of the 305(b) reporting process. Slightly or non-impacted aquatic communities, such as those encountered at all Connecticut stations, *support* the Massachusetts SWQS designated *Aquatic Life* use in addition to meeting the objective of the Clean Water Act (CWA), which is to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters (Environmental Law Reporter 1988). No benthic communities assessed in this study failed to support the *Aquatic Life* use goal of the CWA. This is not to say that stations achieving a designation of *non-impacted* should be considered pristine. There may be stressors affecting water quality, aesthetics, and other biotic communities that have little impact upon the benthic community.

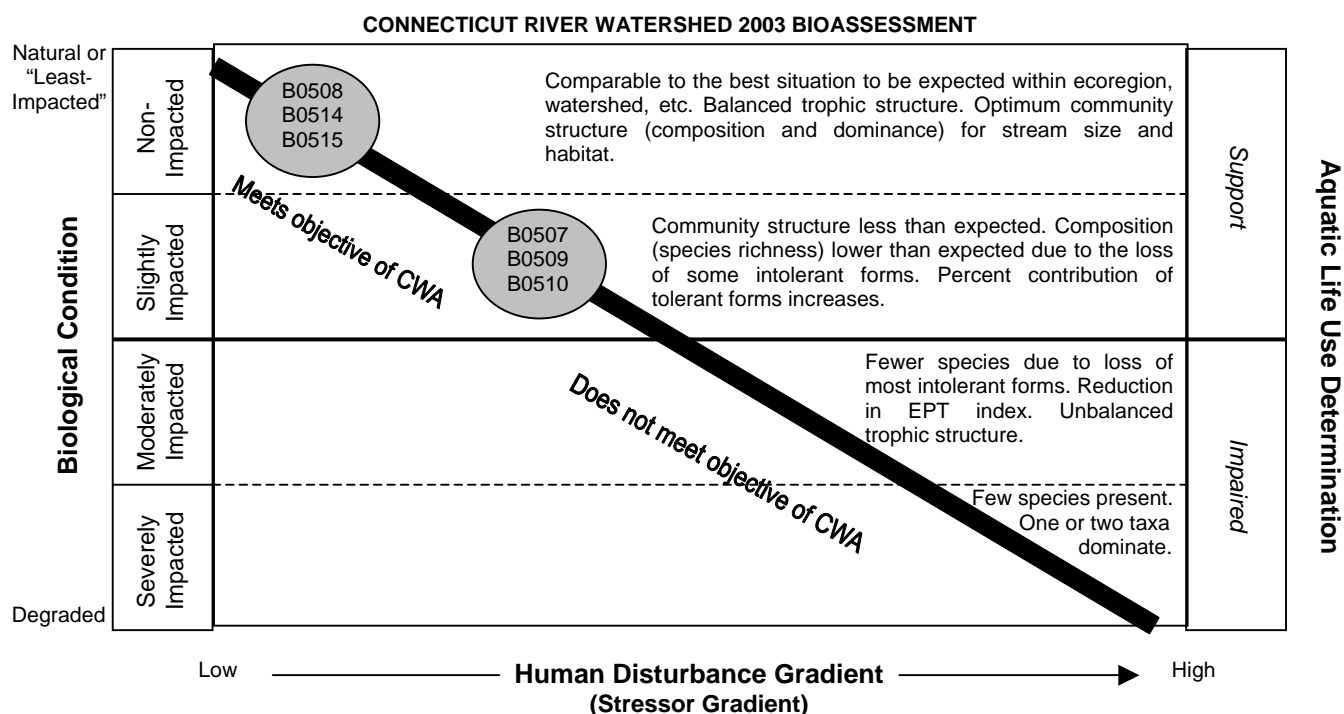


Figure 2. Schematic of the predictive response of aquatic communities to increasing human disturbance. Included is the performance (Biological Condition and Aquatic Life Use determinations) of the Connecticut River watershed 2003 biomonitoring stations along the Human Disturbance Gradient. NOTE: reference station (B0514) is considered to represent the “best attainable” conditions and to be supportive of the *Aquatic Life* use.

Amethyst Brook

Benthos: "Non-Impacted" (Reference Station)
Habitat: 157 / 200

Observations and Recommendations:

B0514 was used as the regional reference station to which all other Connecticut River Watershed benthic stations were compared. Amethyst Brook runs through a high-gradient area from its headwaters (the confluence of Harris Brook and Buffum Brook) all the way through station B0514. The contributing watershed is sparsely populated and mostly forested.

Much of the area surrounding B0514 is conservation land owned by the Town of Amherst. There are many trails that cross, and parallel, Amethyst Brook. These include the Metacomet-Monadnock Trail, and the Robert Frost Trail. Mountain bikers and dog walkers heavily utilize the trails around Amethyst Brook. Although there were obvious signs of recreational use, the trail system did not appear degraded. Nor did there appear to be any major impacts to the stream as a result of recreational activity. The homes on the left side of the brook were set back far enough from the brook so as to not have a major impact on the instream habitat. The Town of Amherst has a history of preserving open space, and maintaining conservation lands. It is recommended that the Town of Amherst continue with its sound trail maintenance and conservation efforts.

Stony Brook

Benthos: "Slightly Impacted"
Habitat: 160 / 200 (100% Comparability to Reference Station)

Observations and Recommendations:

It is highly probable that the aquatic health of Stony Brook could be greatly improved with the application of sound Non-Point Source (NPS) pollution reduction practices. NPS best management practices can reduce the amount of nutrients and toxins that enter surface waters (MassDEP 2006).

Cushman Brook

Benthos: "Non – Impacted"
Habitat: 154 / 200 (98% Comparable to Reference Station)

Observations and Recommendations:

The presence of a gravel pit across State Street from this station indicates that large amounts of gravel and sand occur within the localized soils. It is quite likely that this same gravel deposit extends within the B0508 area. If so, this condition will always leave B0508 exposed to potential stream bank erosion and sediment deposition. Continued good maintenance of trails within this conservation area would tend to reduce future sediment deposition and bank erosion. If erosion and sediment deposition can be reduced, then the health of the aquatic fauna may be improved.

Mill River – Northampton

Benthos: "Slightly Impacted"
Habitat: 149 / 200 (95% Comparable to Reference Station)

Observations and Recommendations:

Many mills were established along the Mill River – Northampton during the industrial revolution. This development required the installation of associated dams to ensure adequate water supply during the summer months. Manufacturing practices, and other development, within the Mill River watershed have had a significant impact upon the instream and riparian habitats. Many of these mills are now gone; yet

many of their impacts (and dams) still exist. The dams pose a barrier to fish passage, and can have a deleterious effect upon habitat, flow, and water chemistry.

The area surrounding B0509 showed signs of heavy recreational pressure. The extensive trail network (on both sides of the examined reach) is often frequented by runners and dog-walkers. The heavy foot traffic has compacted the soils, and removed much of the grasses and herbaceous vegetation. The retaining wall along the left bank has increased the deposition of gravel and cobble onto the right bank. Also, as a result of the left bank retaining wall, spring flooding can only “over bank” on the right bank. This (along with the foot traffic) has reduced the presence of grasses and herbaceous vegetation.

Sound within-watershed development, and remediation of past impacts, should be followed to improve the quality of aquatic life in the Mill River – Northampton. It is quite likely that upstream NPS pollution (including storm-water runoff) is a primary impact to the instream biota. Assessments of storm drains and abutting land use should be made, and remediated as conditions require. Also, upstream dams should be examined to determine if they continue to serve beneficial purposes or may be candidates for removal.

Mill River – Hatfield

Benthos: “Slightly Impacted”

Habitat: 158 / 200 (101% Comparable to Reference Station)

Observations and Recommendations:

The Mill River – Hatfield has two distinctly different habitats. The upstream portion (upstream of Route 116, Deerfield, MA) is very high-gradient and the streambed contains large amounts of bedrock, boulders and cobble. The portion downstream of Route 116 is lower gradient and the streambed contains large amounts of gravel, sand, and mud / muck. B0510 was located in the lower gradient portion of the river. This was done in order to assess the biological condition in response to the largest amount of contributing watershed.

The lower portion of Mill River – Hatfield (downstream of Route 116) parallels Route 91 for much of its course. The result is the straightening of what would otherwise be a meandering river. Also, the proximity of Route 91 greatly increases the potential for road-run off into the river. Road salt, motor oil, and solid waste can easily enter the river. Aside from Route 91, the proximal upstream landuse consists of heavily developed agriculture. While much of this agriculture consists of pastureland, there are also extensive areas of tilled land. Chemical applications, without adequate buffering, can find their way into this river.

Continued monitoring of watershed conditions, such as those being performed by Smith College (Clark Science Center 2000), is recommended. Agricultural Best Management Practices should be followed to reduce the potential for groundwater and stream impacts. Highway maintenance (along Route 91 and Route 116) should be performed with care. Stormwater runoff – from the industrialized portion of South Deerfield – should be mitigated. Monitoring of Bloody Brook should also continue as this stream receives much of the runoff from South Deerfield. Water withdrawal volume from Roaring Brook reservoir should be monitored to assure adequate instream flows in Mill River – Hatfield.

Sawmill River

Benthos: “Non-Impacted”

Habitat: 137 / 200 (87% Comparable to Reference Station)

Observations and Recommendations:

B0515 had the poorest habitat score of all station examined. This is primarily due to livestock having created trails into and through the river. The livestock (primarily cows) have browsed and trampled much of the riparian vegetation. They also contribute manure to the banks and the river. The stream banks are quite prone to erosion within this reach. The stream, at this point, has entered the Connecticut River Valley floor. Here, the sediments are much finer (sand) than those encountered in headwaters (cobble

and boulder). In the presence of conditions such as these, it is important to preserve as much of the stabilizing vegetation as possible.

This portion of the Sawmill River could benefit from a more active land management strategy. Since the pastureland that abuts both sides of the Sawmill River is used for grazing cattle, it may be necessary to apply agricultural BMPs (Best Management Practices). These practices may include the construction of a bridge and fencing to keep cattle out of the river, yet allow them access to both pastures.

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APPENDIX

Macroinvertebrate taxa list, RBPIII benthos analyses, and Habitat evaluations

Table A1. Taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2003 Connecticut River watershed survey July 2003.

TAXON	FFG ¹	TV ²	B0507	B0515	B0514 ³	B0508	B0510	B0509
Hydrobiidae	SC	8	4					
<i>Ferrissia</i> sp.	SC	6						2
Pisidiidae	FC	6	3					
Enchytraeidae	GC	10			1			
<i>Nais behningi</i>	GC	6		1	2	2		1
Lumbriculidae	GC	7		3			3	3
Erpobdellidae	PR	8	1					
<i>Caecidotea communis</i>	GC	8	3					
<i>Hydrachnidia</i>	PR	6			1			1
<i>Baetis</i> (subeq. term.) sp.	GC	6	2		2			8
Baetidae (short term. fil.)	GC	6					2	
Baetidae (subeq. term.)	GC	6		6				
<i>Caenis</i> sp.	GC	6		1				
<i>Serratella</i> sp.	GC	2		3	2			2
Heptageniidae	SC	4	10	2		1	5	5
<i>Epeorus</i> (Iron) sp.	SC	0				1		
<i>Isonychia</i> sp.	GC	2	2					1
Leptophlebiidae	GC	2		2	1			
<i>Habrophlebia</i> sp.	GC	4			1			
<i>Paraleptophlebia</i> sp.	GC	1				5		
Chloroperlidae	PR	1					1	
Leuctridae	SH	0				11		
<i>Leuctra</i> sp.	SH	0			14			
Leuctridae/Capniidae	SH	2		5				
Perlidae	PR	1		1		2		
<i>Acronetia</i> sp.	PR	0			3	2		
<i>Agnetina</i> sp.	PR	2		1		1		
<i>Paragnetina</i> sp.	PR	1	2	1				
<i>Nigronia</i> sp.	PR	0		1				
<i>Nigronia serricornis</i>	PR	0			2			
<i>Brachycentrus</i> sp.	FC	1		1				
Glossosomatidae	SC	0					3	
<i>Agapetus</i> sp.	SC	0		3				
<i>Glossosoma</i> sp.	SC	0		1		2		
<i>Helicopsyche</i> sp.	SC	3		2				
Hydropsychidae	FC	4						1
<i>Cheumatopsyche</i> sp.	FC	5	19		7	1	8	6
<i>betteni</i>	FC	6	15				21	
<i>Hydropsyche morosa</i> gr.	FC	6		7	2	2		4
<i>Lepidostoma</i> sp.	SH	1	1		4			
<i>Oecetis</i> sp.	PR	5	1					
<i>Apatania</i> sp.	SC	3			1			1
Odontoceridae	SH	0			2			
Philopotamidae	FC	3				1		
<i>Chimarra</i> sp.	FC	4	14					3
<i>Dolophilodes</i> sp.	FC	0		1	3			
<i>Polycentropus</i> sp.	PR	6			1			
<i>Rhyacophila</i> sp.	PR	1		1		4		
<i>Neophylax</i> sp.	SC	3	1	3				3
<i>Optioservus</i> sp.	SC	4		21			12	4
<i>Oulimnius latiusculus</i>	SC	4		1	5	1	1	2
<i>Promoresia</i> sp.	SC	2			5	1	5	1
<i>Stenelmis</i> sp.	SC	5	8	3			9	10
<i>Dineutus</i> sp.	PR	4		1			3	
<i>Psephenus herricki</i>	SC	4	3				1	6
<i>Chironomini</i>	GC	6		1				
<i>Microtendipes pedellus</i> gr.	FC	6		1	1			
<i>Microtendipes rydalensis</i> gr.	FC	6			2	1		

TAXON	FFG ¹	TV ²	B0507	B0515	B0514 ³	B0508	B0510	B0509
<i>Polypedilum</i> sp.	SH	6		2				
<i>Polypedilum aviceps</i>	SH	4		3	5	16		
<i>Polypedilum fallax</i>	SH	6					1	1
<i>Polypedilum flavum</i>	SH	6	3	1				2
<i>Micropsectra dives</i> gr.	GC	7			1	3		
<i>Micropsectra polita</i> gr.	GC	7		1	2	5		
<i>Micropsectra/Tanytarsus</i> sp.	FC	7		2		1		
<i>Rheotanytarsus</i> sp.	FC	6	1					
<i>Rheotanytarsus exiguus</i> gr.	FC	6	3	3			2	9
<i>Rheotanytarsus pellucidus</i>	FC	5	4	2	1		1	3
<i>Stempellina</i> sp.	GC	2			1			
<i>Sublettea coffmani</i>	FC	4						7
<i>Tanytarsus</i> sp.	FC	6		8	11	20		
<i>Zavrelia/Stempellinella</i> sp.	GC	4				2		
<i>Diamesa</i> sp.	GC	5	6				13	
<i>Pagastia</i> sp.	GC	1					2	
<i>Potthastia longimana</i> gr.	GC	2		1				
Orthoclaadiinae	GC	5		1				
<i>Corynoneura</i> sp.	GC	4			1			
<i>Cricotopus triannulatus</i>	SH	7						4
<i>Cricotopus vierriensis</i>	SH	7						4
<i>Eukiefferiella</i> sp.	GC	6		1				
<i>Eukiefferiella devonica</i> gr.	GC	4					1	
<i>Nanocladius (Plecopteracoluthus)</i> sp.	GC	3				1		
<i>Parachaetocladius</i> sp.	GC	2			1	3		
<i>Parametrioctenus</i> sp.	GC	5			3	4		
<i>Rheocricotopus</i> sp.	GC	6			1			
<i>Rheocricotopus robacki</i>	GC	5						1
<i>Tvetenia paucunca</i>	GC	5	1		3	7	2	
Tanypodinae	PR	7		1				
<i>Ablabesmyia mallochi</i>	PR	8				1		
<i>Conchapelopia</i> sp.	PR	6		2	2	1	1	1
<i>Chelifera</i> sp.	PR	6						1
<i>Hemerodromia</i> sp.	PR	6		2		1	1	
<i>Simulium</i> sp.	FC	5	2				1	
Tipulidae	SH	5						1
<i>Antocha</i> sp.	GC	3						3
<i>Dicranota</i> sp.	PR	3		1	3	1		
<i>Hexatoma</i> sp.	PR	2				1		
<i>Tipula</i> sp.	SH	6	1		1		1	
TOTAL NUMBER OF ORGANISMS			110	105	98	105	100	101

¹Functional Feeding Group (FFG). The feeding habit of each taxon. SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC-Scraper; PR-Predator.

²Tolerance Value (TV). An assigned value used to calculate the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.

³Reference station

Table A2. Summary of RBP III data analysis for macroinvertebrate communities sampled during the Connecticut River watershed survey – July 2003. Shown are the calculated metric values, metric scores (in italics) based on comparability to the Amethyst Brook (B0514) reference station, and the corresponding assessment designation for each biomonitoring station. Refer to Table 1 for a complete listing and description of sampling stations.

STATION	B0514		B0507		B0508		B0509		B0510		B0515	
STREAM	Amethyst Brook		Stony Brook		Cushman Brook		Mill River - Northampton		Mill River – Hatfield		Sawmill River	
HABITAT SCORE	157		160		154		149		158		137	
TAXA RICHNESS	34	6	23	4	28	6	30	6	24	4	35	6
BIOTIC INDEX	3.48	6	5.05	2	3.86	6	4.98	2	4.70	4	4.31	4
EPT INDEX	12	6	10	4	10	4	9	2	6	0	16	6
EPT/CHIRONOMIDAE	1.23	6	3.72	6	0.51	2	1.06	6	1.74	6	1.37	6
SCRAPER/FILTERER	0.41	6	0.43	6	0.23	6	1.03	6	1.09	6	1.44	6
% DOMINANT TAXON	14%	6	17%	6	19%	6	10%	6	21%	4	20%	4
REFERENCE SITE AFFINITY	100%	6	62%	4	73%	6	76%	6	67%	6	78%	6
TOTAL METRIC SCORE	42		32		36		34		30		38	
% COMPARABILITY TO REFERENCE	100%		76%		86%		81%		71%		90%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	Reference		Slightly Impacted		Non-Impacted		Slightly Impacted		Slightly Impacted		Non-Impacted	

Table A3. Habitat assessment summary for biomonitoring stations sampled during the Connecticut River watershed survey – July 2003. For primary parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For secondary parameters, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Refer to Table 1 for a complete listing and description of sampling stations.

Habitat Parameter	B0514*		B0507		B0508		B0509		B0510		B0515	
Instream Cover	12		7		18		17		16		8	
Epifaunal Substrate	19		17		18		16		18		18	
Embeddedness	16		15		14		14		16		19	
Channel Alteration	18		18		19		13		14		18	
Sediment Deposition	16		14		9		17		13		15	
Velocity-Depth Combinations	10		15		10		18		17		16	
Channel Flow Status	18		17		18		17		9		16	
Bank Vegetative Protection	8 ^L	9 ^R	10	10	9	8	7	4	10	10	5	4
Bank Stability	9	8	9	9	5	7	10	4	9	9	9	4
Riparian Vegetative Zone Width	7	7	9	10	10	9	8	4	8	9	3	2
TOTAL SCORE	157		160		154		149		158		137	

L = Left Bank
R = Right Bank
* = Reference Station

Appendix D

2003 Connecticut River Watershed Fish Population Assessment

Peter Mitchell

Watershed Planning Program
Worcester, MA

January, 2007

CN: 105.4

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Ian Bowles, Secretary
Department of Environmental Protection
Arleen O'Donnell, Acting Commissioner
Bureau of Resource Protection
Glenn Haas, Acting Assistant Commissioner
Division of Watershed Management
Glenn Haas, Director

The Massachusetts Division of Watershed Management (MA DWM) conducted fish population surveys on the Connecticut River and selected tributaries during September and October of 2003. Sampling was conducted as part of a comprehensive water quality monitoring project by MA DWM. Surveys of the resident fish populations were conducted at a total of six stations (Table 1). Surveys were conducted using techniques similar to Rapid Bioassessment Protocol V (fish) as described by Barbour et al (1999).

Fish Population Sample Collection, Processing, and Analysis

Fish populations were sampled by electrofishing using a Coffelt Mark 18 gas-powered backpack electrofisher. A reach of between 80m and 100m was sampled by passing a pole-mounted anode ring side to side through the stream channel and in and around likely fish holding cover. All stunned fish were netted and held in buckets. Sampling proceeded from an obstruction or constriction, upstream to an endpoint at another obstruction or constriction such as a waterfall or shallow riffle. Following completion of a sampling run, all fish were identified to species, measured, weighed, and released.

The RBP V protocol (Barbour et al. 1999) calls for the analysis of the data generated from fish collections using an established Index of Biotic Integrity (IBI) similar to that described by Karr et al. (1986). Since no formal IBI for Massachusetts currently exists, the data provided by this sampling effort were used to qualitatively assess the general condition of the resident fish population as a function of the overall abundance (number of species and individuals) and species composition classifications listed below.

1. Tolerance Classification - Classification of tolerance to environmental stressors similar to that provided in Barbour et al. (1999), and Halliwell et al. (1999). Final tolerance classes are those provided by Halliwell et al. (1999).
2. Macrohabitat Classification – Classification by common macrohabitat use as presented by Bain and Knight (1996) modified regionally following discussions with MA DEP and MA Division of Fisheries and Wildlife (DFW) biologists.
3. Trophic Classes- Classification which utilizes both dominant food items as well as feeding habitat type as presented in Halliwell et al.(1999).

For a more complete explanation of MA DWM fish collection procedures, please see CN75.1 “Fish Collection Procedures for Evaluation of Resident Fish Populations” (Mass DEP 2003). Tabulated results of the fish population surveys can be found in Table 3.

Habitat Assessment

These surveys also included a habitat assessment component modified from Rapid Bioassessment Protocols V (Barbour et al. 1999). Recording site characteristics and rating habitat qualities is important to the interpretation of biomonitoring data. The habitat data and assessments help distinguish between pollution impacts and habitat limitations. These data can also help identify causes of habitat destruction and loss.

Habitat assessment is accomplished by a visual-based method (Barbour et al. 1999) conducted at the time of sample collection. Each of ten habitat categories is rated from 0 (lowest, “poor”) to 20 (highest, “optimal”). The ten categories are: Instream cover (fish); Epifaunal substrate (in sampled portions of reach); Embeddedness; Channel alteration; Sediment deposition; Velocity-depth combinations; Channel flow status; Bank vegetative protection (each bank scored separately for a maximum of 10 points each); Bank stability (each bank scored separately for a maximum of 10 points each); Riparian vegetated zone width (each bank scored separately for a maximum of 10 points each). Descriptions of the considerations for scoring each habitat category can be found in Barbour et al. (1999). Tabulated results of this habitat assessment can be found in Table 2. For a more in-depth examination of habitat conditions, and benthic communities, see Connecticut River Watershed 2003 Biological Assessment (CN 105.3)(Mitchell 2006).

Results

The Connecticut River Watershed was affected by above-average rainfall during the time of sampling (MA DCR. Online). This condition resulted in slightly elevated water levels, decreased water temperatures, and an increase of available habitat as expressed by the high “channel flow status” habitat scores in Table 2.

Station Specific Conditions and Findings:

Cushman Brook

Most of the habitat measures were found to be within the “optimal” range. Channel Flow Status, Instream Fish Cover, Epifaunal Substrate, Channel Alteration, Velocity-Depth Combinations, and Bank Vegetative Protection were all within the “optimal” habitat range (see Table 2). The habitat parameters Embeddedness, Sediment Deposition, Bank Stability, and Riparian Vegetative Zone Width were rated as “suboptimal”. The reduction in these habitat parameters is most likely due to the abundance of sand and gravel in the surrounding area – as is evidenced by the sand and gravel pit across South Street from the sampled reach. This potentially unstable geologic condition leaves the stream banks prone to erosion and the substrates prone to embeddedness. The suboptimal rating of the Riparian Vegetative Zone Width was due to the proximity of State Street near the right bank, and frequently utilized trails along the left bank. The total habitat score arrived at for this fish population survey was 167/200. This represents the second best habitat score of all six stations examined within the Connecticut River Watershed in 2003.

Electro-fishing efficiency was rated as excellent. Five fish species were collected from this station. Intolerant, Fluvial Specialist / Dependant, Top Carnivore, Cold-water species dominated the 42 fish collected at this station (Halliwell et al. 1999, Bain and Meixler 2000). The collected 26 brown trout (*Salmo trutta*) and the one brook trout (*Salvelinus fontinalis*) represented cold-water species. The 26 brown trout (70mm – 210mm) seem to represent multiple age classes, as evidenced by the variety of fish lengths. Although brown trout are considered cold-water species, they have a higher thermal tolerance. (Wismer and Christie 1987, New Mexico Environment Department 1999, Brungs and Jones 1977). Although Cushman Brook appears to support a healthy, cold-water fish population, the abundance of brown trout may pose a competitive threat to sensitive native fishes, such as brook trout.

Falls River

As was the case with Cushman Brook, the Channel Flow Status here was rated as “optimal” (18/20). The river at this sampled reach flows through a sparsely populated valley, with old farms on either side. There is an extensive (> 18 meters – “optimal”) riparian buffer zone on river right, but an abbreviated buffer (< 6 meters – “marginal”) between the hay field and the river left bank. The fish population survey noted “optimal” habitat ratings for all parameters with exceptions regarding Bank Vegetative Protection on the left bank (“suboptimal”), and Bank Stability on the right bank (“suboptimal”). The overall habitat score was 175 / 200. This was the best habitat score of all six stations sampled in the Connecticut River Watershed in 2003.

Electro-fishing efficiency was rated as “excellent”. Seven fish species were collected during this survey. Blacknose dace (*Rhinichthys atratulus*, n=122) numerically dominated the 157 fish collected. The collected fish were dominated by tolerant, fluvial specialist / dependant, generalist feeding species. The 11 slimy sculpin (*Cottus cognatus*), 5 Atlantic salmon, and 5 brook trout made up the cold-water species collected at this site. The slimy sculpin appear to have a lower tolerance to heat than do any of the salmonids (Wismer and Christie, 1987). This reach appears to be capable of supporting a cold-water fishery.

Mill River - Hadley

Although located near the Amherst WWTF, the discharge from that plant is to the Connecticut River and not Mill River – Hadley. The Mill River – Hadley, at this reach, flows south, between Route 116 and the UMass/Amherst parking lots and ball fields. Upstream of this reach, the river receives the outfall from

Campus Pond and the storm water runoff from the Umass/Amherst coal-cinder parking lot. The reach is within the Connecticut River Valley floor. As such, the river is of relatively low gradient with a sandy bottom. As was the case at all stations examined during the 2003 Connecticut River Watershed fish population surveys, the abundance of rainfall placed the Channel Flow Status habitat parameter within the "optimal" range. The Epifaunal Substrate habitat parameter was rated as "poor" (3 / 20), due to the lack of any significant riffles, and the abundance of sand. Embeddedness and Sediment Deposition habitat parameters were rated as "marginal" (7/20 and 8/20 respectively). This was also due to the prevalence of sand. The Velocity-Depth Combinations habitat parameter was also rated as "marginal" (8/20), due to the lack of variety of conditions. The Channel Alteration was rated as "suboptimal", due to diversion created by Route 116. The Bank Stability was also rated as "suboptimal", due to the steep, and unstable, sand banks. The total habitat score for the Mill River – Hadley site was 112/200. This is the poorest score of all stations examined in the watershed in 2003.

Electro-fishing efficiency was rated as "poor". Due to the depth, and width, of the stream, some fish were not captured. Eight fish species were collected in this reach. The 15 individual fish collected were dominated by moderately tolerant, and fluvial specialist / dependant species. Only the one collected rainbow trout (*Oncorhynchus mykiss*) was considered to be a cold-water species. It appears that proximal warm water habitats are influencing the fish community within this reach.

East Branch Mill River - Northampton

The East Branch Mill River – Northampton flows, for the most part, through a sparsely populated, forested watershed. It is not until the stream enters the sampled reach that the surrounding area may be considered "thickly-settled".

The Channel Flow Status and Instream Cover were rated as "optimal". There were a great variety of snags, undercut banks, and stable habitat throughout the sampled reach. Sediment Deposition was rated as "suboptimal", with some noticeable increases of gravel and sand affecting the substrate. This may be due, in part, to the Bank Stability (rated as "marginal"). The banks were observed to be moderately unstable, with ~50% of the banks displaying signs of erosion. The Riparian Vegetative Zone Width was rated as "suboptimal" due to the proximity of lawns. The total habitat score for the East Branch Mill River – Northampton was 166 / 200.

Electro-fishing efficiency was rated as "excellent". Eight fish species were collected during this fish survey. The 60 individual fish collected during this survey were almost equally divided between "Intolerant" and "Tolerant" species. The collected fish were numerically dominated by Fluvial Specialist / Dependant species, Generalist Feeder species. Twelve salmonids (11 brook trout, and 1 brown trout) were collected at this station. The lengths of the collected brook trout ranged from 75mm to 190mm, and point towards a reproducing population of these fish. The 12 salmonids, and the 14 slimy sculpin, are representatives of cold-water species. The collected fish assemblage is indicative of excellent water and habitat quality.

West Branch Mill River - Northampton

Human development appears greater within the West Branch watershed than the East Branch watershed. The West Branch parallels and crosses Route 9 for much of its course. Aside from the increase in commercial and residential development along Route 9, sections of the stream banks have been stabilized in order to prevent damage to Route 9.

The Channel Alteration habitat parameter was rated as "suboptimal". Much of the river-right bank has been stabilized with large stone and rip-rap. The Velocity-Depth Combinations parameter was rated as "marginal". The West Branch displayed a lack of variety of flow regimes, and a uniform depth throughout the sampled reach. The proximity of Route 9 and the commercial development decreased the Riparian Vegetative Zone Width parameter rating along the right-bank to "marginal". A parking lot beyond the stone retaining wall has replaced a vegetated riparian zone. The total habitat score for the West Branch Mill River – Northampton was 162 / 200.

Electro-fishing efficiency was rated as “excellent”. Six fish species were collected during this survey. The thirty-one collected fish were numerically dominated by “Intolerant”, “Fluvial Specialist / Dependant”, “Benthic Insectivore” species. Included in the sample were eight Atlantic salmon (*Salmo salar*) and one brook trout. The nine collected salmonids and nine slimy sculpin are all cold-water species, and accounted for the majority of the collected fish. This stream appears capable of supporting a healthy fish community and indicates excellent habitat and water quality.

Stony Brook

Stony Brook begins its course in Granby, MA and is relatively low-gradient until after it emerges from the two ponds (Upper Pond and Lower Pond) on the Mount Holyoke College campus. After the two ponds, Stony Brook picks up gradient and then parallels Route 116. It then flows underneath Route 116 and enters the sampled reach.

As with the other sampled reaches, the Channel Flow Status was rated as “optimal”. However, the Instream Cover was rated as “marginal”. Only about 20% of the sampled reach had a mix of stable habitat, and the substrates appeared frequently disturbed. The Embeddedness and Sediment Deposition habitat parameters both were rated as “suboptimal”. The substrate was quite sandy, and the sand filled in around many of the larger stones and cobbles. The Velocity – Depth Combinations parameter was also rated as “suboptimal”. Aside from one high velocity pool at the top of the reach, the channel was relatively uniform in terms of depth and velocity. All other habitat parameters were within the “optimal” range.

Although electro-fishing efficiency was rated as “good”, it is possible that some fish escaped capture due to the width of the stream. The total number of fish collected was low ($n = 20$) and the species present included a number of macrohabitat generalists. These included redbreast sunfish, bluegill, smallmouth and largemouth bass, chain pickerel and pumpkinseed. Collected fluvial species included longnose dace, tessellated darter, Atlantic salmon, and white sucker. The variety of macrohabitat generalist species collected indicates that the sampled stream reach is well connected to lower gradient habitats. Slow, meandering stream habitats exist downstream of the sampled reach, and continue to the confluence with the Connecticut River. It is likely that macrohabitat generalists are entering the stream reach from these downstream habitats.

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Table 1: 2003 Connecticut Watershed Fish Population Station Locations

Waterbody	Location	Lat. / Lon.	Date
Cushman Brook	In Amherst Con-Com Park, south side of State Street, Amherst	42.24.56/ 72.30.41	17 September 2003
Falls River	Upstream of Bascom Road, Gill	42.38.42/ 72.32.32	17 September 2003
Mil River - Hadley	North of Amherst WWTP, east of Route 116, Amherst	42.23.18/ 72.32.20	17 September 2003
East Branch Mill River - Northampton	Left side of Mill Road, Williamsburg	42.23.32/ 72.43.38	23 October 2003
West Branch Mill River - Northampton	End of Mill Road, Williamsburg	42.23.31/ 72.43.40	23 October 2003
Stony Brook	West of Route 116, South Hadley	42.14.45/ 72.34.53	23 October 2003

Table 2: Habitat assessment summary for fish population stations sampled during the 2003 Connecticut River Watershed survey. For instream parameters, scores ranging from 16-20 = Optimal; 11-15 = Suboptimal; 6-10 = Marginal; 0-5 = Poor. For bank and riparian parameters, each bank was scored separately. Scores ranging from 9-10 = Optimal; 6-8 = Suboptimal; 3-5 = Marginal; 0-2 = Poor. Refer to Table 1 for a listing and description of sampling stations.

Habitat Parameter	Cushman Brook		Falls River		Mill River - Hadley		East Branch Mill River - Northampton		West Branch Mill River - Northampton		Stony Brook	
Instream Cover	19		18		11		19		18		7	
Epifaunal Substrate	18		18		3		18		18		18	
Embeddedness	13		19		7		17		18		12	
Channel Alteration	19		19		11		20		13		18	
Sediment Deposition	13		17		8		13		19		12	
Velocity-Depth Combination	18		20		8		19		10		12	
Channel Flow Status	17		18		18		19		18		16	
Bank Vegetative Protection	9(L)	9(R)	7	9	9	9	9	9	9	7	9	9
Bank Stability	8	8	9	8	6	6	4	4	9	9	9	9
Riparian Vegetative Zone - Width	8	8	4	9	7	9	8	7	9	5	10	10
TOTAL SCORE	167		175		112		166		162		151	

(L) = Left Bank

(R) = Right Bank

Table 3. Fish population data collected by DWM at six biomonitoring stations in the Connecticut River Watershed on 17 September and 23 October 2003. Refer to Table 1 for a listing and description of sampling stations.

TAXON (SORTED BY FAMILY)	Habitat Class ¹	Trophic Class ²	Tolerance Class ³	Cushman Brook	Falls River	Mill River - Hadley	Stony Brook	East Branch Mill River - Northampton	West Branch Mill River - Northampton
American eel <i>Anguilla rostrata</i>	MG	TC	T	--	--	--	1	--	--
common shiner <i>Luxilus cornutus</i>	FD	GF	M	--	--	--	--	9	1
Eastern blacknose dace <i>Rhinichthys atratulus</i>	FS	GF	T	13	122	--	--	12	8
longnose dace <i>Rhinichthys cataractae</i>	FS	BI	M	1	9	1	6	--	4
creek chub <i>Semotilus atromaculatus</i>	FS	GF	T	--	4	--	--	9	--
fallfish <i>Semotilus corporalis</i>	FS	GF	M	--	--	4	--	--	--
slimy sculpin <i>Cottus cognatus</i>	FS	BI	I	--	11	--	--	14	9
white sucker <i>Catostomus commersonii</i>	FD	GF	T	1	--	1	1	3	--
tessellated darter <i>Etheostoma olmstedii</i>	FS	BI	M	--	--	4	1	--	--
Atlantic salmon <i>Salmo salar</i>	FD	TC	I	--	5	--	2	--	8
rainbow trout <i>Oncorhynchus mykiss</i>	FD	TC	I	--	--	1	--	--	--
brown trout <i>Salmo trutta</i>	FD	TC	I	26	--	--	--	1	--
brook trout <i>Salvelinus fontinalis</i>	FD	TC	I	1	5	--	--	11	1
yellow bullhead <i>Ameiurus natalis</i>	MG	GF	T	--	--	2	--	--	--
chain pickerel <i>Esox niger</i>	MG	TC	M	--	--	--	2	1	--
redbreast sunfish <i>Lepomis auritus</i>	MG	GF	M	--	--	--	1	--	--
bluegill <i>Lepomis macrochirus</i>	MG	GF	T	--	--	1	1	--	--
smallmouth bass <i>Micropterus dolomieu</i>	MG	TC	M	--	--	--	2	--	--
largemouth bass <i>Micropterus salmoides</i>	MG	TC	M	--	--	--	1	--	--
pumpkinseed <i>Lepomis gibbosus</i>	MG	GF	M	--	1	--	2	--	--
Central mudminnow <i>Umbra limi</i>	FD	GF	T	--	--	1	--	--	--
Total Number of Fish Collected	-	-	-	42	157	15	20	60	31

¹Habitat Class - FS (fluvial specialist), FDR (fluvial dependant reproduction), MG (macrohabitat generalist). From Bain and Meixler (2000), modified for Massachusetts

²Trophic Class - GF (generalist feeder), BI (benthic invertivore), TC (top carnivore), WC (water column invertivore). From Halliwell et al. (1999)

³Tolerance Classification - I (intolerant), M (moderately tolerant), T (tolerant). From Halliwell et al. (1999) Classification described as tolerance to "environmental perturbation".

Appendix E

CONNECTICUT RIVER WATERSHED

2003 Chlorophyll a and Periphyton Technical Memorandum

Joan Beskenis

Watershed Planning Program
Worcester, MA

December, 2006

CN: 105.7

**Commonwealth of Massachusetts
Executive Office of Environmental Affairs**

Robert W. Golledge, Jr., Secretary

Department of Environmental Protection

Arleen O'Donnell, Acting Commissioner

Bureau of Resource Protection

Glenn Haas, Acting Assistant Commissioner

Division of Watershed Management

Glenn Haas, Director

Introduction

Biological assessment was performed by personnel from the Massachusetts Department of Environmental Protection (MassDEP) at several stations in the Connecticut River Basin during the summer of 2003. Because the Connecticut River is a large, often deep, often slow river, it can maintain a resident population of phytoplankton. In order to learn more about the phytoplankton biomass in this river, chlorophyll *a* samples were collected to gather information on the main stem water quality and to determine if it was impacted by sources of nutrients (phosphorus and nitrogen) located along the river; in particular, agricultural runoff and discharges from wastewater treatment plants. Chlorophyll *a* is a pigment that is found in all plants and algae and provides an estimate of biomass as well as an indication of the biological production of the water body.

In the tributaries, samples were collected for the identification of periphyton, described here as including the attached microscopic and macroscopic algae. Estimates were made of the percent algal cover within the riffle of the sampling reach. Algal type and abundance were also recorded. Periphyton sampling was limited to sites chosen for macroinvertebrate/habitat investigations.

Objectives of the periphyton sampling were to provide additional information for assessment by adding another biological community to the macroinvertebrate and habitat information, and to examine temporal changes in the amount and type of algae present in the assemblage. The periphyton assessment provides information to aid in determining if the designated uses, as described in the Surface Water Quality Standards (MassDEP 1996), are being supported, threatened or lost in particular segments. Periphyton data can be used to evaluate two designated uses of the Connecticut River: Aquatic Life and Aesthetics.

Aquatic life evaluations determine if suitable habitat is available for "sustaining a native, naturally diverse, community of aquatic flora and fauna." Natural diversity and the presence of native species may not be sustained when there are dense growths of a monoculture of a particular alga. This alteration of the community structure may indicate that the aquatic life use support is lost or threatened. Loss of parts of the food web, which is vital for aquatic life use support, may result from this alteration. In addition, the die-off and decomposition of large amounts of biomass from macroalgae can fill in the interstitial sites in the substrate and destroy this habitat for the benthic invertebrates and compromise the aquatic life use support.

The algal data are also used to determine if aesthetics have been impacted. Floating rafts of previously attached benthic mats can make a waterbody visually unappealing, as can large areas of the bottom substrates covered with long streamers of algae that can discourage waders and hinder fishermen by making the substrata slippery for walking. Fishermen can also snag their fishing lines on the filamentous algae. Nuisance amounts of algae, which can compromise aesthetics, can be determined by estimating the percent macroalgal cover in a particular habitat (e.g. riffles or pool) (Biggs 1996) (Barbour et al. 1999). Nuisance amounts of macroalgae are present, if the percent cover is greater than 40 % by filamentous green algae (Biggs 1996) (Barbour et al. 1999).

Periphyton sampling is typically done on first, second or third order streams and rivers that are small, shallow, and often fast moving. At each of the stations an estimate of the percent cover of the periphyton and benthic algae is made and samples are collected for algal identification. Periphyton samples are typically scrapes of one type of substrata in the riffle zone. The algal scrapes are used in the qualitative microscopic examination to determine the presence and relative abundance of the phyla that contributes the most to the biomass in the riffle or pool habitats. The estimate of percent cover of the filamentous algae (macroalgae) is used in conjunction with the microscopic examination to determine if uses of the river (Aquatic Life Support and Aesthetics) are lost or threatened because of excessive algal growth.

Materials and Methods

Chlorophyll a

Samples for chlorophyll *a* analysis and phytoplankton identifications were collected on July 9, Aug. 6 and Sept. 10 by reaching into the main flow of the river using a pole with a sample container attached. Grab samples were collected just below the surface in plastic containers that were placed into iced coolers until they could be returned to MassDEP's laboratory in Worcester for analysis. Samples were processed within the 24-hour holding period. A list of chlorophyll *a* sampling stations is included in Table 1 and shown in Figure 1.

A Turner Designs, Inc. TD-700 fluorometer was used in the chlorophyll *a* analysis (MassDEP 2000). Fifty milliliters of sample water were filtered through a glass fiber filter. The filter was ground using a motor driven grinder and a glass pestle. The ground material was transferred to plastic centrifuge tubes that were kept in the dark and refrigerated for 24 hours while the chlorophyll *a* extraction continued in 90% acetone. The plastic centrifuge tubes were kept in the dark, brought to room temperature, and then decanted into borosilicate disposable cuvettes that were placed in the TD-700 fluorometer for analysis. Results are reported in mg chlorophyll *a* per m³ water.

Table 1. 2003 Connecticut River Chlorophyll a Sampling Locations		
Station ID	Location	Mile Point
CT06	Connecticut River -Route 10 Bridge, Northfield	64.4
02A	Connecticut River -Downstream of Fourmile Brook confluence, Northfield and east of Pisgah Mountain Rd., Gill	58.7
04A	Connecticut River -Route 116, Deerfield/Sunderland	40.2
04C	Connecticut River -Upstream of the confluence of the Mill River, near the Oxbow, Northampton/Hadley	22.4
05A	Connecticut River -Route 90 boat launch, West Springfield/Chicopee	9.9
CT00	Connecticut River -At the USGS flow gage #01184000 downstream of Route 190, Suffield/Enfield, Connecticut	-2.9
07A	Bachelor Brook -At Route 47 (Hadley St.), South Hadley	0.9
11A	Manhan River -Loudville Rd., Easthampton	5.6
11C	Manhan River -Fort Hill Rd., Easthampton	0.8
27B	Fort River -At Route 47, Hadley	0.6
24B	Mill River -Maple St., Hatfield	2.1
BB01	Bloody Brook -Whately Rd., Deerfield	1.6
25C	Mill River -Mill River Lane, Hadley	0.9

The map displays the Connecticut River Watershed, bounded by major basins: Deerfield River Watershed to the northwest, Westfield River Watershed to the west, and Chicopee River Watershed to the east. The river flows from north to south through the center of the map. Major towns labeled include Greenfield, Northfield, Westfield, Springfield, and Hartford. Numerous sampling stations are marked with red dots and labeled with codes in boxes: CT06, 02A, CT05, CT04, 01A, 01B, 01C, 01D, 01E, 01F, 01G, 01H, 01I, 01J, 01K, 01L, 01M, 01N, 01O, 01P, 01Q, 01R, 01S, 01T, 01U, 01V, 01W, 01X, 01Y, 01Z, 02A, 02B, 02C, 02D, 02E, 02F, 02G, 02H, 02I, 02J, 02K, 02L, 02M, 02N, 02O, 02P, 02Q, 02R, 02S, 02T, 02U, 02V, 02W, 02X, 02Y, 02Z, 03A, 03B, 03C, 03D, 03E, 03F, 03G, 03H, 03I, 03J, 03K, 03L, 03M, 03N, 03O, 03P, 03Q, 03R, 03S, 03T, 03U, 03V, 03W, 03X, 03Y, 03Z, 04A, 04B, 04C, 04D, 04E, 04F, 04G, 04H, 04I, 04J, 04K, 04L, 04M, 04N, 04O, 04P, 04Q, 04R, 04S, 04T, 04U, 04V, 04W, 04X, 04Y, 04Z, 05A, 05B, 05C, 05D, 05E, 05F, 05G, 05H, 05I, 05J, 05K, 05L, 05M, 05N, 05O, 05P, 05Q, 05R, 05S, 05T, 05U, 05V, 05W, 05X, 05Y, 05Z, 06A, 06B, 06C, 06D, 06E, 06F, 06G, 06H, 06I, 06J, 06K, 06L, 06M, 06N, 06O, 06P, 06Q, 06R, 06S, 06T, 06U, 06V, 06W, 06X, 06Y, 06Z, 07A, 07B, 07C, 07D, 07E, 07F, 07G, 07H, 07I, 07J, 07K, 07L, 07M, 07N, 07O, 07P, 07Q, 07R, 07S, 07T, 07U, 07V, 07W, 07X, 07Y, 07Z, 08A, 08B, 08C, 08D, 08E, 08F, 08G, 08H, 08I, 08J, 08K, 08L, 08M, 08N, 08O, 08P, 08Q, 08R, 08S, 08T, 08U, 08V, 08W, 08X, 08Y, 08Z, 09A, 09B, 09C, 09D, 09E, 09F, 09G, 09H, 09I, 09J, 09K, 09L, 09M, 09N, 09O, 09P, 09Q, 09R, 09S, 09T, 09U, 09V, 09W, 09X, 09Y, 09Z, 10A, 10B, 10C, 10D, 10E, 10F, 10G, 10H, 10I, 10J, 10K, 10L, 10M, 10N, 10O, 10P, 10Q, 10R, 10S, 10T, 10U, 10V, 10W, 10X, 10Y, 10Z, 11A, 11B, 11C, 11D, 11E, 11F, 11G, 11H, 11I, 11J, 11K, 11L, 11M, 11N, 11O, 11P, 11Q, 11R, 11S, 11T, 11U, 11V, 11W, 11X, 11Y, 11Z, 12A, 12B, 12C, 12D, 12E, 12F, 12G, 12H, 12I, 12J, 12K, 12L, 12M, 12N, 12O, 12P, 12Q, 12R, 12S, 12T, 12U, 12V, 12W, 12X, 12Y, 12Z, 13A, 13B, 13C, 13D, 13E, 13F, 13G, 13H, 13I, 13J, 13K, 13L, 13M, 13N, 13O, 13P, 13Q, 13R, 13S, 13T, 13U, 13V, 13W, 13X, 13Y, 13Z, 14A, 14B, 14C, 14D, 14E, 14F, 14G, 14H, 14I, 14J, 14K, 14L, 14M, 14N, 14O, 14P, 14Q, 14R, 14S, 14T, 14U, 14V, 14W, 14X, 14Y, 14Z, 15A, 15B, 15C, 15D, 15E, 15F, 15G, 15H, 15I, 15J, 15K, 15L, 15M, 15N, 15O, 15P, 15Q, 15R, 15S, 15T, 15U, 15V, 15W, 15X, 15Y, 15Z, 16A, 16B, 16C, 16D, 16E, 16F, 16G, 16H, 16I, 16J, 16K, 16L, 16M, 16N, 16O, 16P, 16Q, 16R, 16S, 16T, 16U, 16V, 16W, 16X, 16Y, 16Z, 17A, 17B, 17C, 17D, 17E, 17F, 17G, 17H, 17I, 17J, 17K, 17L, 17M, 17N, 17O, 17P, 17Q, 17R, 17S, 17T, 17U, 17V, 17W, 17X, 17Y, 17Z, 18A, 18B, 18C, 18D, 18E, 18F, 18G, 18H, 18I, 18J, 18K, 18L, 18M, 18N, 18O, 18P, 18Q, 18R, 18S, 18T, 18U, 18V, 18W, 18X, 18Y, 18Z, 19A, 19B, 19C, 19D, 19E, 19F, 19G, 19H, 19I, 19J, 19K, 19L, 19M, 19N, 19O, 19P, 19Q, 19R, 19S, 19T, 19U, 19V, 19W, 19X, 19Y, 19Z, 20A, 20B, 20C, 20D, 20E, 20F, 20G, 20H, 20I, 20J, 20K, 20L, 20M, 20N, 20O, 20P, 20Q, 20R, 20S, 20T, 20U, 20V, 20W, 20X, 20Y, 20Z, 21A, 21B, 21C, 21D, 21E, 21F, 21G, 21H, 21I, 21J, 21K, 21L, 21M, 21N, 21O, 21P, 21Q, 21R, 21S, 21T, 21U, 21V, 21W, 21X, 21Y, 21Z, 22A, 22B, 22C, 22D, 22E, 22F, 22G, 22H, 22I, 22J, 22K, 22L, 22M, 22N, 22O, 22P, 22Q, 22R, 22S, 22T, 22U, 22V, 22W, 22X, 22Y, 22Z, 23A, 23B, 23C, 23D, 23E, 23F, 23G, 23H, 23I, 23J, 23K, 23L, 23M, 23N, 23O, 23P, 23Q, 23R, 23S, 23T, 23U, 23V, 23W, 23X, 23Y, 23Z, 24A, 24B, 24C, 24D, 24E, 24F, 24G, 24H, 24I, 24J, 24K, 24L, 24M, 24N, 24O, 24P, 24Q, 24R, 24S, 24T, 24U, 24V, 24W, 24X, 24Y, 24Z, 25A, 25B, 25C, 25D, 25E, 25F, 25G, 25H, 25I, 25J, 25K, 25L, 25M, 25N, 25O, 25P, 25Q, 25R, 25S, 25T, 25U, 25V, 25W, 25X, 25Y, 25Z, 26A, 26B, 26C, 26D, 26E, 26F, 26G, 26H, 26I, 26J, 26K, 26L, 26M, 26N, 26O, 26P, 26Q, 26R, 26S, 26T, 26U, 26V, 26W, 26X, 26Y, 26Z, 27A, 27B, 27C, 27D, 27E, 27F, 27G, 27H, 27I, 27J, 27K, 27L, 27M, 27N, 27O, 27P, 27Q, 27R, 27S, 27T, 27U, 27V, 27W, 27X, 27Y, 27Z, 28A, 28B, 28C, 28D, 28E, 28F, 28G, 28H, 28I, 28J, 28K, 28L, 28M, 28N, 28O, 28P, 28Q, 28R, 28S, 28T, 28U, 28V, 28W, 28X, 28Y, 28Z, 29A, 29B, 29C, 29D, 29E, 29F, 29G, 29H, 29I, 29J, 29K, 29L, 29M, 29N, 29O, 29P, 29Q, 29R, 29S, 29T, 29U, 29V, 29W, 29X, 29Y, 29Z, 30A, 30B, 30C, 30D, 30E, 30F, 30G, 30H, 30I, 30J, 30K, 30L, 30M, 30N, 30O, 30P, 30Q, 30R, 30S, 30T, 30U, 30V, 30W, 30X, 30Y, 30Z, 31A, 31B, 31C, 31D, 31E, 31F, 31G, 31H, 31I, 31J, 31K, 31L, 31M

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Periphyton Identifications and Relative Abundance

Periphyton samples were gathered along with the macroinvertebrate samples and habitat information using methods described in Barbour et al (1999). Sampling was done by the macroinvertebrate sampling crew and consisted of randomly scraping rocks and cobble substrates, typically within the riffle area, but other habitats were occasionally sampled. Material was removed with a knife or by hand from rock substrata and then added to labeled glass vials containing sample water. Table 3 contains descriptions of the station locations where periphyton was collected. The samples were transported to the lab at MassDEP-Worcester in one liter plastic jars containing stream water to keep them cool. Once at the lab, they were refrigerated until identifications were completed. Samples held longer than a week were preserved using M³ with a dose rate of 2 ml of preservative per 100 ml of sample (Reinke 1984).

Vials were shaken to get uniform samples before subsampling. Filamentous algae were removed first, identified separately and then the remainder of the sample was examined. An Olympus BH2 compound microscope with Nomarski optics was used for the identifications (Appendix B contains the references used for identifications). Slides were typically examined under 200 power. A modified method for periphyton analysis developed by Bahls (1993) was used. The scheme developed by Bahls for determining abundance on a slide is as follows:

R (rare)	fewer than one cell per field of view at 200x, on the average;
C (common)	at least one, but fewer than five cells per field of view;
VC (very common)	between 5 and 25 cells per field;
A (abundant)	more than 25 cells per field, but countable;
VA (very abundant)	number of cells per field too numerous to count.

A visual determination was also made of whether or not the algal covering was composed of micro or macroalgae, in particular, the green filamentous algae. The microalgae typically appear as a thin film, often green or blue-green, or as a brown floc. Macroalgal (green filamentous algae) cover over greater than 40% of the substrata in the riffle/run is considered to be indicative of organic enrichment (Barbour et al 1999) to the extent that the aesthetic quality of the stream may be compromised.

Results

Chlorophyll a

Channel characteristics of the Connecticut River, such as depth and retention time, favor the establishment of an indigenous phytoplankton population. The biomass of the phytoplankton was estimated by determining the chlorophyll a concentration in a water column sample. The chlorophyll results remained fairly constant over the sampling period (Table 2) as most stations exhibited the same value or less than a 1.0 mg/m³ change from July to September. Exceptions to this were station 11 C on the Manhan River which had its highest algal production in August (5.1 mg/m³ chlorophyll a) but then dropped in September to 1.8 mg/m³. Bloody Brook (BB01) peaked in July at 8.8 mg/m³, but then decreased in August and September.

Table 2. 2003 Connecticut River Water-column Chlorophyll a Data (mg/m ³)				
Station ID	Water Column color/transparency	Sampling Dates		
		July 9	August 6	September 10
CT06	Water typically colored brown	<1.0	1.0	<1.0
02A	Water column was usually clear	<1.0 (1.1)*	1.3 (1.1)	1.6 (1.7)
04A	Water column slightly turbid and brown	<1.0 (<1.0)	--	<1.0
04C	Slightly turbid, brown	<1.0	1.3	1.1
05A	Water was typically slightly turbid, and brown	1.4	1.0	1.7
CT00	Water column clear	--	1.7 (1.6)	2.3
07A	Water always colored tan or brown and turbid	--	1.3	<1.0
11A	Water usually clear, yet low gradient and pasture land	--	2.1	<1.0
11C	Water brown colored	--	5.1	1.8
27B	Water was brown and turbid	--	3.1	<1.0
24B	Slightly turbid, brown	1.3	--	--
BB01	Water usually brown	8.8 (7.9)	3.2 (5.7)	3.4
25C	Water was usually slightly turbid and brown	1.5 (1.3)	--	--
* Values for duplicate samples appear in parentheses				

Periphyton

The three periphyton sampling locations, their percent canopy cover and percent algal cover are described in Table 3. Appendix A lists algal genera that were identified at these sites.

Table 3. 2003 Periphyton samples from selected Connecticut River Tributaries				
Unique ID	Location	% Canopy Cover	% Algal Cover	Dominant Algae in riffle
B0510	Mill River (Hatfield), ~100-meters upstream of Mountain Drive, below the confluence of West Brook, Hatfield, MA	50	65	Filamentous cyanobacteria <i>Phormidium</i> VA.
B0507	Stony Brook, ~30-meters upstream of powerlines, downstream from Route 116, South Hadley, MA	90	2	Filamentous green <i>Cladophora glomerata</i> and diatom <i>Cocconeis</i> sp.
B0515	Sawmill River, upstream at South Ferry Road, Montague, MA	70	30	Diatom chain (<i>Melosira brevigulata</i>)- planktonic, lake organisms

The Stony Brook station (B0507) had only 2% algal cover, and a high percentage of the river bottom was shaded by the canopy (90%) (Table 3). Isolated clumps of the green filamentous alga *Cladophora glomerata* were recovered in the algal scrapes (Table 3, Appendix A).

At the Mill River location (B0510) the percent algal cover was high at 65% with filamentous cover in the riffle dominated by the cyanobacteria-*Phormidium* sp. Although *Phormidium* sp. covered a large part of the substrata, the short microscopic filaments do not have the same nuisance factor as macroscopic algae. Canopy cover here was the lowest of the three stations at 50%.

According to field sheets, non-point source pollution was evident at the Sawmill River in Montague (B0515). Cows had access to the river at this station and their droppings were found in the riparian zone. The water column was slightly turbid and had a grayish color. The diatom chain *Melosira brevigulata* was a major constituent of the periphyton that covered 30% of the substrata in the riffle.

Discussion

Algal production, as indicated by the chlorophyll *a* values, was low at the stations included for sampling at the Connecticut River. As indicated in Table 3, many of the stations had highly colored and often turbid water. Agricultural land-use is prevalent throughout this watershed. In the technical memorandum presenting the 2003 water quality data for the Connecticut River Mitchell (2005) mentions possible sources for the turbidity present in the water column. The turbidity may have resulted from the sandy soil types that formed the banks of the river in several areas like CT06, 11A, 11C, where slumping or erosion of sandy/muddy banks was noted (Mitchell 2005). This common phenomenon along the Connecticut River could be caused by erosion of lake-bottom deposits (Typically clay, silt and sand) that are prevalent along both sides of the river-remnants of glacial Lake Hitchcock, which extended up to the Massachusetts border with Vermont.

Other sources of turbidity could be from non-point source run-off. Stations 02A-Northfield, 27 B-Amherst and 25C-University of Massachusetts all receive run-off from towns. Station 11C is located 0.75 miles below the Easthampton Wastewater Treatment Plant, another source of solids and nutrients to the river. Agricultural run-off may impact stations 02A, 05A, 11A, 27B and 25 C (Mitchell 2005).

The turbid and colored waters may have limited algal productivity by reducing available light penetration. Chlorophyll *a* values (an indicator of algal production) were often 1 mg/m³ or less from stations that stretched from mile point 64.4 down to mile point -2.9 at CT00 in Enfield, Connecticut.

A closed canopy appeared to affect periphyton production at tributary sites including B0507 and B0515. A significant inverse relationship (r^2 equal to .9959 ($F=0.040783$)) was found in a regression using % algal cover (*y*) and % canopy cover (*x*).

In areas with elevated nutrients and open canopy the green filamentous alga *Cladophora glomerata* is often found in abundance. The growth of this alga at B0507 might be more luxuriant if the canopy was more open.

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Appendix A: 2003 Connecticut River Tributary Periphyton - Algal Taxonomic Identifications and Abundance Data					
Unique ID	Location	Date	Family	Genus/Species	Abundance*
B0515	Sawmill River, upstream at South Ferry Road, Montague, MA	22-July	Bacillariophyceae	<i>Fragilaria</i> sp.	C
			Bacillariophyceae	<i>Melosira brevigulata</i>	VA
			Bacillariophyceae	<i>Synedra</i> sp.	C
			Bacillariophyceae	<i>Ui** pennate diatoms</i>	R
			Chlorophyceae	<i>Chlamydomonas</i> sp.	C
			Chlorophyceae	<i>Closterium</i> sp.	C
			Chlorophyceae	<i>Scenedesmus</i> sp.	C
			Chlorophyceae	<i>Spirogyra</i> sp.	C
			Chlorophyceae	<i>Ui** desmids</i>	C
			Cyanophyceae	<i>Oscillatoria</i> sp.	R
B0507	Stony Brook, ~30-meters upstream of powerlines, downstream from Route 116, South Hadley, MA	22-July	Bacillariophyceae	<i>Cocconeis</i> sp.	VA
			Chlorophyceae	<i>Cladophora glomerata</i>	VA
B0510 Sample 1	Mill River (Hatfield), ~100-meters upstream of Mountain Drive, below the confluence of West Brook, Hatfield, MA	23-July	Bacillariophyceae	<i>Cymbella</i> sp.	R
			Bacillariophyceae	<i>Cyclotella</i> sp.	R
			Bacillariophyceae	<i>Navicula</i> sp.	A
			Bacillariophyceae	<i>Pinnularia</i> sp.	R
			Bacillariophyceae	<i>Surirella</i> sp.	R
			Chlorophyceae	<i>Scenedesmus</i> sp.	R
			Chlorophyceae	<i>Staurastrum</i> sp.	R
			Cyanophyceae	<i>Phormidium</i> sp.	VA
			Euglenophyceae	<i>Euglena</i> sp.	R
B0510 Sample 2	Mill River (Hatfield), ~100-meters upstream of Mountain Drive, below the confluence of West Brook, Hatfield, MA	23-July	Bacillariophyceae	<i>Cocconeis</i> sp.	VA
			Bacillariophyceae	<i>Cyclotella</i> sp.	VC
			Chlorophyceae	<i>Closterium</i> sp.	R
			Chlorophyceae	<i>Microspora</i> sp.	R
			Chlorophyceae	<i>Ulothrix</i> sp.	A
			Chlorophyceae	<i>ui** filament</i>	VC
			Cyanophyceae	<i>Cylindrocapsa</i> sp.	A

* R (rare)
C (common)
VC (very common)
A (abundant)
VA (very abundant)

** unidentified

Appendix B: References Used for Taxonomic Identifications of the Algae

- Collins, F. S. 1970. *Green Algae of North America*. Bibliotheca Phycologica, Band 11. Verlag von J. Cramer. New York. 106 p., 11 plates
- Cox, E. J. 1996. *Identification of Freshwater Diatoms from Live Material*. Chapman and Hall. London. 158 p.
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- Hansmann, E. W. 1973. *Diatoms of the Streams of Eastern Connecticut*. State Geological and Natural History Survey of Connecticut. Dept. Of Environmental Protection. Hartford. 119 p.
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- Smith, G. M. 1950. *The Fresh-water Algae of the United States*. 2 nd edit. McGraw Hill Publishers. New York. 719 p.
- Prescott, G. W. 1982. *How to Know the Freshwater Algae*. WmC. Brown. New York. 293 p.
- VanLandingham, S. L. *Guide to the Identification, Environmental Requirements and Pollution Tolerance of Freshwater Blue-green Algae (Cyanophyta)*. Environmental Monitoring and Support Laboratory. U.S. Environmental Protection Agency. Cincinnati.
- Weber, C.I. 1971. *A Guide to the Common Diatoms at Water Pollution Surveillance System Stations*. U. S. Environmental Protection Agency. Cincinnati. 101 p.
- Whitford, L. A. and G. J. Schumacher. 1984. *A Manual of Fresh-Water Algae*. Sparks Press. Raleigh. 337 p.

APPENDIX F

MASSDEP DWM 2003 LAKE SURVEY DATA IN THE CONNECTICUT RIVER WATERSHED

From Baseline Lake Survey 2003, Technical Memo CN 205.0.

In the Connecticut River Watershed, baseline lake surveys were conducted in July and September 2003. Metacomet Lake and Upper Highland Lake were each sampled on one occasion. Data were excerpted from the *Baseline Lake Survey 2003* Technical Memorandum (MassDEP 2007) and are presented in tables F1 and F2.

In-situ measurements using the Hydrolab® (measures dissolved oxygen, water temperature, pH, conductivity, and depth and calculates total dissolved solids and % oxygen saturation) were recorded. At deep hole stations measurements were recorded at various depths to create profiles. In-lake samples were also collected and analyzed for alkalinity, total phosphorus, apparent color, and chlorophyll *a* (an integrated sample). Procedures used for water sampling and sample handling are described in the *Grab Collection Techniques for DWM Water Quality Sampling Standard Operating Procedure* and the *Hydrolab® Series 3 Multiprobe Standard Operating Procedure* (MassDEP 1999a and MassDEP 1999b). The Wall Experiment Station (WES), MassDEP's analytical laboratory, supplied all sample bottles and field preservatives, which were prepared according to the *WES Laboratory Quality Assurance Plan and Standard Operating Procedures* (MassDEP 1995). Samples were preserved in the field as necessary, transported on ice to WES, and analyzed according to the WES Standard Operating Procedure (SOP). Information about data quality objectives (accuracy, precision, detection limits, holding times, representativeness and comparability) is available in the 2003 Data Validation Report (MassDEP 2005). Apparent color and chlorophyll *a* were measured according to standard procedures at the MassDEP DWM office in Worcester (MassDEP 2002a and MassDEP 2002b). No aquatic macrophyte survey was conducted at either lake.

Table F1. 2003 MassDEP DWM Connecticut River Watershed Baseline Lakes *physico-chemical* data.

CONNECTICUT RIVER/Metacomet Lake

Unique ID: W1068 Station: A

Description: deep hole, Belchertown

Date	Secchi	Secchi Time	Station Depth	OWMID	QAQC	Time	SmpTyp	RelDepth ¹	Sample Depth	Chl-a	NO3-NO2-N	TKN	TN	TP	AppColor
	m	24hr	m			24hr			m	mg/m3	mg/L	mg/L	mg/L	mg/L	PCU
07/09/03	2.1	11:45	4.3												
				LC-0053	--	11:50	VDOR	nb	3.5	--	--	--	--	##* m	--
				LC-0051	LC-0052	11:37	MNGR	--	<0.5	--	--	--	--	##* m	35*
				LC-0052	LC-0051	11:37	MNGR	--	<0.5	--	--	--	--	##* m	36*
				LC-0055	--	11:53	DINT	--	0 - 3.5	11.9*	--	--	--	--	--

CONNECTICUT RIVER//Upper Highland Lake

Unique ID: W1080 Station: A

Description: deep hole, southern end, Goshen

Date	Secchi	Secchi Time	Station Depth	OWMID	QAQC	Time	SmpTyp	RelDepth ¹	Sample Depth	Chl-a	NO3-NO2-N	TKN	TN	TP	AppColor
	m	24hr	m			24hr			m	mg/m3	mg/L	mg/L	mg/L	mg/L	PCU
09/03/03	3.5	10:13	4.5												
				LC-0059	--	10:35	VDOR	nb	4.2	--	<0.02	--	## bh	0.012	--
				LC-0058	--	10:30	MNGR	--	<0.5	--	<0.02	--	## bh	0.009	27*
				LC-0060	LC-0061	10:50	DINT	--	0 - 3.5	2.4*	--	--	--	--	--
				LC-0061	LC-0060	10:55	DINT	--	0 - 3.5	1.9*	--	--	--	--	--

¹ Relative depth key: nb = near bottom.

Table F2. 2003 MassDEP DWM Connecticut River Watershed Baseline Lakes *in-situ* data.

CONNECTICUT RIVER//Metacomet Lake, Unique ID: W1068 Station: A

Description: deep hole, Belchertown

Date	OWMID	Time (24hr)	Depth (m)	Temp (°C)	pH (SU)	Cond@ 25C (uS/cm)	TDS (mg/L)	DO (mg/L)	SAT (%)
07/09/03									
	LC-0056	10:48	0.5	28.1	6.5 u	127	81.0	8.0	104
	LC-0056	10:58	1.5	26.9	6.2	128	81.9	6.8 u	87 u
	LC-0056	11:28	1.7	24.6 u	5.8	124	79.2	5.5 u	68 u
	LC-0056	11:05	2.0	23.2	6.1	121	77.6	3.9 u	46 u
	LC-0056	11:12	2.5	18.7	6.2 u	119	76.3	0.6	7
	LC-0056	11:19	3.0	15.6	6.2 u	124	79.1	0.4	4

CONNECTICUT RIVER//Upper Highland Lake, Unique ID: W1080 Station: A

Description: deep hole, southern end, Goshen

Date	OWMID	Time (24hr)	Depth (m)	Temp (°C)	pH (SU)	Cond@ 25C (uS/cm)	TDS (mg/L)	DO (mg/L)	SAT (%)
09/03/03									
	LC-0062	10:46	0.1 i	20.4	6.8 u	34.0	22.0	7.4	82
	LC-0062	10:49	0.5	20.4	6.8	34.0	22.0	7.3	81
	LC-0062	10:52	0.8	20.4	6.8	34.0	22.0	7.3	81
	LC-0062	10:55	1.4	20.4	6.9	34.0	22.0	7.3	81
	LC-0062	10:57	1.9	20.4	6.9	35.0	23.0	7.3	81
	LC-0062	10:59	2.5	20.4	6.9 c	34.0	22.0	7.3	81
	LC-0062	11:03	2.9	20.4	6.9 c	34.0	22.0	7.3	81
	LC-0062	11:05	3.5	20.4	6.9 c	34.0	22.0	7.2 u	80 u
	LC-0062	11:08	4.0	20.4	6.9	34.0	22.0	7.1 u	79 u

Data Qualifiers

The following data qualifiers or symbols used in the MassDEP/DWM Water Quality Database (WQD) have been applied to qualify or censor these water quality and multi-probe data. Decisions regarding censoring vs. qualification for specific, problematic data are made based on a thorough review of all pertinent information related to the data.

General Symbols (applicable to all types):

“ ## ” = Censored data (i.e., data that has been discarded for some reason). NOTE: Prior to 2001 data,

“**” denoted either censored or missing data.

“ ** ” = Missing data (i.e., data that should have been reported). See NOTE above.

“ -- ” = No data (i.e., data not taken/not required)

* = Analysis performed by Laboratory OTHER than DEP’s Wall Experiment Station (WES)

[] = A result reported inside brackets has been “censored”, but is shown for informational purposes (e.g., high blank results).

Multi-probe-specific Qualifiers:

“ i ” = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey calibration readings outside typical acceptance range for the low ionic check and for the deionized blank water check, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses.

“i” = General Depth Criteria: Apply to each OWMID#

- Clearly erroneous readings due to faulty depth sensor: Censor (i)
- Negative and zero depth readings: Censor (i); (likely in error)
- 0.1 m depth readings: Qualify (i); (potentially in error)
- 0.2 and greater depth readings: Accept without qualification; (likely accurate)

Specific Depth Criteria: Apply to entirety of depth data for survey date

- If zero and/or negative depth readings occur more than once per survey date, censor all negative/zero depth data, and qualify all other depth data for that survey (indicates that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, ie. that all positive readings may be in error.)

“ u ” = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly-variable water quality conditions, etc. See Section 4.1 for acceptance criteria.

“ c ” = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified (“c”) conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading). See Section 4.1 for acceptance criteria.

Sample-Specific Qualifiers:

“ b ” = blank Contamination in lab reagent blanks and/or field blank samples (indicating possible bias high and false positives).

“ h ” = holding time violation (usually indicating possible bias low)

“ m ” = method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (eg. sediment in sample, floc formation), lab error (eg. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

Sample codes for sampling:

OWMID: Office of Watershed Management Identification Code for the bottle.

QAQC: the OWMID codes (e.g. LB-1903) refer to the field duplicate sample (usually immediately above or below in the table) to be compared with the current sample.

Time: Local time.

SymTyp: Sample Type- VDOR= Van Dorn; DINT= Depth integrated by vertical hose; MNGR= Manual Grab; NR= not recorded.

RelDepth: Relative Depth- s= Near Surface; m= middle depth; nb= near bottom.

References

MassDEP. 1995. January Draft *Laboratory Quality Assurance Plan and Standard Operating Procedures* Massachusetts Department of Environmental Protection, Division of Environmental Analysis, Wall Experiment Station, Lawrence, MA.

MassDEP. 1999a. *Grab Collection Techniques for DWM Water Quality Sampling Standard Operating Procedure* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA

MassDEP. 1999b. *Hydrolab® Series 3 Multiprobe Standard Operating Procedure* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA.

MassDEP. 2002a. *Standard Operating Procedures for Apparent Color, CN2.1* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA

MassDEP. 2002b. *Standard Operating Procedures for Chlorophyll a, CN3.2* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA

MassDEP. 2005. *Data Validation Report for Year 2003 Project Data, CN 211.0.* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA.

MassDEP. 2007. *Baseline Lake Survey 2003, Technical Memorandum CN 205.0.* Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA.

APPENDIX G

MassDEP DWM 2002 Fish Toxics Monitoring in the Connecticut River Watershed

INTRODUCTION

Fish contaminant monitoring is a cooperative effort between three Massachusetts Department of Environmental Protection (MassDEP) Divisions/Offices (Watershed Management (DWM), Environmental Analysis, and Research and Standards), the Massachusetts Department of Fish and Game, and the Massachusetts Department of Public Health (MA DPH). Fish contaminant monitoring is designed to screen the edible fillets of several species of fish desired by the angling public for consumption, as well as species representing different feeding guilds (i.e., bottom dwelling omnivores, top-level predators, etc.) for the presence of heavy metals (Pb, Cd, Se, Hg, As), polychlorinated biphenyls (PCBs), and organochlorine pesticides. These data are used by the MA DPH in assessing human health risks associated with the consumption of freshwater fishes.

In the Connecticut River Watershed fish contaminant monitoring surveys were conducted by MassDEP DWM staff in Lower Mill Pond in Easthampton in 2002. The objective of these surveys was to screen the edible fillets of fishes for potential contaminants (e.g., selected metals, PCBs and organochlorine pesticides). All results were submitted to the MA DPH for review.

Project Objectives

Fish contaminant monitoring is typically conducted to assess the levels of toxic contaminants in freshwater fish, identify waterbodies where those levels may impact human health, and identify waters where toxic chemicals may impact fish and other aquatic life. Nonetheless, human health concerns have received higher priority and, therefore, fish tissue analysis has been restricted to edible fillets. The fish toxics monitoring was designed to screen the edible fillets of several species of fish representing different feeding groups (i.e., bottom-dwelling omnivores, top-level predators, etc.) for the presence of heavy metals, PCBs and chlorinated pesticides.

Fish toxics monitoring conducted in 2002 followed guidance in the Quality Assurance Project Plan (QAPP) for Fish Toxics Monitoring (MassDEP 2003). Data quality objectives are presented in the above-mentioned QAPP.

METHODS

Field Methods

Uniform protocols, designed to assure accuracy and prevent cross-contamination of samples, were followed for collecting, processing and shipping fish (MassDEP 2003 and MassDEP 2005). The characteristics of each site determine the method(s) of sample collection. Lower Millpond was sampled by DWM using boat electrofishing and trot line collection methods. Electrofishing was performed by maneuvering the boat through the littoral zone and shallow water habitat of a given waterbody and collecting most fish shocked. Fish collected by electrofishing were stored in a live well filled with site water until the completion of sampling. Fish to be included in the sample were stored on ice and transported to the DWM laboratory in Worcester.

DWM Laboratory Methods (Sample processing)

Fish brought to the MassDEP DWM laboratory in Worcester were processed using protocols designed to assure accuracy and prevent cross-contamination of samples (MassDEP 2003 and MassDEP 2005). Specimen lengths and weights were recorded along with notes on tumors, lesions, or other anomalies noticed during an external visual inspection. Species, length, and weight data can be found in Table G1. Fish were filleted (skin off) on glass cutting boards and prepared for freezing. All equipment used in the filleting process was rinsed in tap water and then rinsed twice in de-ionized water before and or after each sample. Samples (individual or composite) targeted for % lipids, PCBs and organochlorine pesticide analysis were wrapped in aluminum foil. Samples targeted for metals analysis were placed in VWR high density polyethylene (HDPE) cups with covers. Composite samples were composed of three fillets from like-sized individuals of the same species (occasionally the same genus). Samples were tagged and frozen for subsequent delivery to the MassDEP's Wall Experiment Station (WES).

WES Laboratory Methods (Analytical)

Mercury analysis were conducted using EPA Method 245.1. This is a cold vapor method using a Perkin Elmer, FIMS (Flow Injection Mercury System), which uses Flow Injection Atomic Absorption Spectroscopy. All analyses for cadmium, lead and selenium were conducted using EPA Method 200.7. Cadmium and lead were analyzed using a Perkin Elmer, Optima 3000 XL ICP - Optical Emission Spectrophotometer. Arsenic and selenium were analyzed using a Perkin Elmer, Zeeman 5100 PC, Platform Graphite Furnace, Atomic Absorption

Spectrophotometer. PCB arochlor, PCB congener, and organochlorine pesticide analysis was performed on a gas chromatograph equipped with an electron capture detector “according to the modified AOAC 983.21 procedure for the analysis of PCB arochlors, congeners, and organochlorine pesticides” (Maietta *et al.* 2004). Additional information on analytical techniques used at WES is available from the laboratory.

RESULTS

Electrofishing at Lower Mill Pond in East Hampton on 6/6/02 resulted in the collection of three largemouth bass, three yellow perch, and three bluegill. Trotlines set overnight and retrieved on 6/7/02 resulted in the collection of three yellow bullhead. Additional species observed included pumpkinseed, chain pickerel, American eel, white perch, white sucker, and bowfin *Amia calva*.

All fish tissue data met DWM data quality objectives and passed quality control acceptance limits of the WES laboratory unless otherwise noted below (Maietta *et al.* 2004).

“Fish tissue data passed the QC acceptance limits of the WES laboratory. WES reported a number of lab-validated data with “qualification”. All but one of these “qualified” data points were for very low concentrations of either PCBs (Congeners and Arochlors) and/or organochlorine pesticides. One data point for arsenic at the detection limit was also qualified. The lab fortified matrix spike recovery for toxaphene was 50% resulting in “J” (estimated) qualification by WES. These QC data suggest potential poor recovery of toxaphene in samples. Lab accuracy estimates for metals (all analytes) using lab-fortified matrix samples were acceptable ranging from 80-112 % recovery except for two selenium samples at 126 and 128 % recovery and one lead sample at 130% recovery. QC sample recoveries were acceptable ranging from 83-117%. Lab accuracy estimates for metals (all analytes) using lab fortified blanks were acceptable ranging from 82 to 111 % recovery except for one lead sample at 128% recovery.

All quality assurance and quality control data are available from the laboratory upon request.

Fish toxics monitoring survey data can be found below in Table G1 (excerpted from Maietta *et al.* 2004).

Table G1. Analytical Results for 2002 Lower Millpond Fish Toxics Monitoring Survey. Results reported in wet weight, are from composite samples of fish fillets with skin off.

Sample ID	Collection Date	Species Code ¹	Length (cm)	Weight (g)	Sample ID (laboratory sample #)	Cd (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	As (mg/kg)	Se (mg/kg)	% Lipids (%)	PCB Aroclors and Congeners (µg/g)	Pesticides (µg/g)
Lower Mill Pond, Easthampton, Connecticut River Watershed													
LMF02-1	6/6/02	LMB	31.9	400	2002020 (L2002192-1)	<0.040	<0.20	0.33	<0.060	0.18	0.05	A1254-0.020J A1260-0.038J BZ#180-0.0048	DDE-0.0076J
LMF02-2	6/6/02	LMB	33.4	470	(L2002196-1)							BZ#170-0.0022J	
LMF02-3	6/6/02	LMB	32.3	420									
LMF02-4	6/6/02	YP	26.1	220	2002021 (L2002192-2)	<0.040	<0.20	0.12	<0.060	0.34	0.21	BZ#118-0.0012J	ND
LMF02-5	6/6/02	YP	25.6	200	(L2002196-2)								
LMF02-6	6/6/02	YP	25.7	210									
LMF02-7	6/6/02	B	20.4	160	2002022 (L2002192-3)	<0.040	<0.20	0.08	<0.060	0.22	0.12	A1260-0.025J BZ#118-0.0015J BZ#180-0.0042	DDE-0.0064J
LMF02-8	6/6/02	B	20.1	160	(L2002196-3)							BZ#170-0.0019J	
LMF02-9	6/6/02	B	19.4	150									
LMF02-10	6/7/02	YB	29.2	340	2002023 (L2002192-4)	<0.040	<0.20	0.12	<0.060	0.14	0.79	A1260-0.10 BZ#118-0.0035J BZ#180-0.020	Chlor ² -0.064J DDE-0.015J
LMF02-11	6/7/02	YB	24.7	220	(L2002196-4)							BZ#170-0.0034J	
LMF02-12	6/7/02	YB	27.0	260									

¹ Species Code Common Name Scientific name
 (B) bluegill *Lepomis macrochirus*
 (LMB) largemouth bass *Micropterus salmoides*
 (YB) yellow bullhead *Ameiurus natalis*
 (YP) yellow perch *Perca flavescens*

² - Chlordane

ND - not detected or the analytical result is at or below the established method detection limit (MDL).

J-estimated value, concentration <RDL or certain QC criteria not met

RDL = reporting detection limit

< = result not detected above method detection limit, unless otherwise noted

REFERENCES

MassDEP. 2003. CN096.0. *Quality Assurance Project Plan for Fish Toxics Monitoring*. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MassDEP. 2005. CN040.1. *Standard Operating Procedure for Fish Toxics Monitoring Fish Collection and Preparation*. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

Maietta, R. J. undated. *1983-2004 Fish Toxics Monitoring Survey List*. CN219.0. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. (TM-S-18).

Maietta, R. J., J. Ryder, and R.F. Chase. 2004. CN099.0. *2002 Fish Toxics Monitoring Public Request and Year 2 Watershed Surveys*. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

**APPENDIX H
SUMMARY OF WMA REGISTRATION AND PERMITTING
AND NPDES PERMITTING INFORMATION
CONNECTICUT RIVER BASIN**

DRAFT

Table H1. Water Management Act registration and permits in the Connecticut River Watershed.

Registration#	Permit	Water Supply System Name	Registered Volume (MGD)	Registered Withdrawal (Days)	Permitted Volume (MGD)	Permit Withdrawal (Days)	Segment	PWSID
10600802	9P10600801	Amherst DPW Water Division	3.34	365	1.21	365	MA34-27 subwatershed: five wells - 01G, 02G, 04G, 05G, 06G, and one inactive 07G MA34006 (01S -Atkins Reservoir) MA34-35 (02S -Amythest Brook Hawley Hill Intake)	1008000
	9P10619202	Australis Aquaculture, LLC	NA	NA	0.41	365	MA34-03 (Well #1)	
	9P10602401	Belchertown Water District	NA	NA	0.4	365	MA34-27 subwatershed (05G Daigle Well)	1024000
	9P010602901	Bernardston Fire & Water District	NA	NA	0.17	365	MA34-33 (03G Sugarhouse Well)	1029000
	9P210633701	Chang Farms, Inc	NA	NA	0.15	365	MA34-04 (onsite wellfield)	
10600502		Crestview Country Club	0.06	184	0	184	MA34-05 (Wells #1, 2, 3 and country club pond)	
	9P2010602902	Crumpin Fox Club	NA	NA	0.08	210	MA34-33 (well #1 and a pond)	
10628904		Delta Sand And Gravel, Inc.	0.11	365	NA	NA		
10611705		Earle M. Parsons & Sons, Inc.	1.03	90	NA	NA	MA34-04 (01S Connecticut River)	
	9P210621702	East Northfield Water Company	NA	NA	0.14	365	MA34-01 (01S Grandin Reservoir)	1217001
10608701	9P210608701	Easthampton Water Department	3.31	365	0	365	MA34-11 (07G Maloney Well) MA34-18 (04G Hedrick Street , 08G Nonotuck Park, 05G Pines Well, and 09G Well #9)	1087000
	9P210608501	Elmcrest Country Club	NA	NA	0.226	183		
10632501		Fountain Plating Co, Inc.	0.12	365	NA	NA	Tributary to MA34-05 (FP Well #1 and #2)	
	9P210621703	Four Star Farms, Inc.	NA	NA	0.167	150	MA34-02 (01S)	
10628902	9P210628901	Great Swamp Farm, Inc.	0.21	365	0.39	365	Subwatershed of MA34-25 (S3, S4, Podick Brook)	
10611702	9P210611701	Hadley Water Department	0.79	365	0.13	365	Subwatershed of MA34-04(01G and 02G Mt. Warner wells) MA34-27 (03G and 04G Callahan wells)	1117002
10612702		Hatfield Water Department	0.35	365	NA	NA	Tributary to MA34-24 (01S	1127000

Registration#	Permit	Water Supply System Name	Registered Volume (MGD)	Registered Withdrawal (Days)	Permitted Volume (MGD)	Permit Withdrawal (Days)	Segment	PWSID
							Running Gutter Brook Reservoir, 01G Running Gutter Brook Well, 02G Omasta Well)	
10613701		Hazen Paper Company	0.13	365	NA	NA	MA34-05 (01G, 02G, and 03G Wells near 3 rd level canal Holyoke)	
10600803		Hickory Ridge Country Club	0.06	184	NA	NA	MA34-27 (surface withdrawal Fort River)	
10613708		Holyoke Gas & Electric Department	0.61	365	NA	NA	MA34-05 (Intake #01 and #02)	
10613711		Holyoke Water Works	8.04	365	NA	NA	MA34-18 (02G Pequot Well) MA34089, and MA34101	1137000
10627501		Intelicoat Technologies	0.2	365	NA	NA	Tributary to MA34-05 (01G Well#1)	
	9P210627502	Ledges Golf Club	NA	NA	0.89	214	MA34-04 (Connecticut River Intake)	
10615902		Longmeadow Country Club	0.1	184	NA	NA	MA34-21 (Longmeadow Country Club Pond)	
10606102		Mckinstry Market Garden	0.1	92	NA	NA	MA34-04 (Connecticut River Surface supply)	
10628903		Mohawk Trout Hatchery	1.44	365	NA	NA	Tributary subwatershed to MA34-04 (Well)	
10613712		Mt Tom Generating Company, LLC.	113.6	365	NA	NA	MA34-04 (Connecticut River intake)	
	9P210612001	New Hampden Country Club	NA	NA	0.135	365	Tributary to MA34-30 (Unlined irrigation ponds, greenhouse well, maintenance shed well, clubhouse well, caretakers well)	1120008 for clubhouse well
10621401	9P210621401	Northampton Department Of Public Works	3.96	365	0.84	365	Tributaries to MA34-28 (01G and 02G), MA34056 (01S), MA34059 (03S), tributary system to MA34-24 (04S), and MA34076 (02S emergency only)	1214000
10607401		Nourse Farms, Inc.	0.2	184	NA	NA	MA34-04 (five surface withdrawals Long Plain Road, Home Pump #2, Home Pump #3, Field Farm #4, and MAGDYZ #6 and one well Dripline #1)	
	9P10613701	Open Square Properties, LLC.	NA	NA	0.235	365	MA34-05 (Well 1A Holyoke	

Registration#	Permit	Water Supply System Name	Registered Volume (MGD)	Registered Withdrawal (Days)	Permitted Volume (MGD)	Permit Withdrawal (Days)	Segment	PWSID
							Canals)	
10613706		Sonoco Products Company	0.85	365	NA	NA	MA34-05 (Sonoco Intake Holyoke Canals)	
10607402		South Deerfield Water District	0.65	365	NA	NA	Tributary to MA34-24 (01S Roaring Brook Dam and 02S Whately Reservoir) and MA34-04 (01G Sugarloaf Street Wellfield)	1074001
10627502		South Hadley Fire District 2 Water Dept.	0.68	365	NA	NA	MA34-04 (04G Dry Brook well and 05G Dry Brook Backup Well which is currently inactive), MA34-07 (Elmer Brook Dug well 03G is an emergency source)	1275001
10627602		Southampton Country Club	0.1	180	NA	NA	MA34-17 (Moose Brook Pumphouse)	
	9P210627601	Southampton Water Department	NA	NA	0.36	365	MA34-11 (Glendale Well 01G and replacement 02G)	1276000
10619203		Southworth Paper Company	0.88	365	NA	NA	MA34-03 (Surface withdrawals #1 and #2)	
10628901		Sunderland National Salmon Station	0.28	365	NA	NA	MA34-25 (Wells #1, 2, and 3)	
10628907	9P210628902	Sunderland State Fish Hatchery	2.79	365	0	365	Tributary to MA34-04 (Sunderland Hatchery Well and Well #2 and Bitzer Hatchery Well)	
10628905		Sunderland Water District	0.24	365	NA	NA	Tributary to MA34-04 (Ralicki Well 01G and Sawmill Brook Reservoir) and MA34-09 (Hubbard Well 02G)	1289000
10600501		Tuckahoe Turf Farm	0.07	153	NA	NA	Tributary to Connecticut River in Connecticut (five surface water withdrawals)	
10619201	9P10619201	Turners Falls Fire District	1.04	365	0.14	365	MA34070 (Lake Pleasant 02S and Hannegan Brook Well 03G) MA34028 (Green Pond 03S) MA34-41 (Well Station 01G and Gravel Pack Well #2 02G)	1192000
10615901		Twin Hills Country Club	0.1	184	NA	NA	MA34-21 subwatershed (no source identified in database)	
	9P210628101	Veterans & Franconia Golf Courses	NA	NA	0.2	210	Upstream MA34073 (Pecousic Brook withdrawal)	

Registration#	Permit	Water Supply System Name	Registered Volume (MGD)	Registered Withdrawal (Days)	Permitted Volume (MGD)	Permit Withdrawal (Days)	Segment	PWSID
							Upstream MA34099 (South Branch Mill River withdrawal)	
	9P201061610 1	Westover Municipal Golf Course	NA	NA	0.12	210	MA34-19 (Wade Pond)	
	9P210633901	Wilbraham Water Department	NA	NA	0.864	365	Upstream MA34052 (Well #1)	1339000
10634001		Williamsburg Water Department	0.2	365	NA	NA	MA34-38 (South Street Wells #1 and #2)	1340000

Notes: NA=Not Applicable

One voluntary registrant Wyckoff Country Club, Inc. V10613705

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Table H2. NPDES permittees in the Connecticut River Watershed.

PERMITTEE Town of Agawam	NPDES # MA0101320	SEGMENT 34-05
The Town of Agawam permit (MA0101320 issued in September 1995) to discharge combined sewer overflows via Outfall #012 (Leonard Street Overflow) to the Connecticut River was terminated by EPA in September 2000.		
PERMITTEE Agri-Mark, Inc.	NPDES # MA0029327	SEGMENT Tributary to MA34-05
Agri-Mark, Inc. in West Springfield (MA0029327 issued in May 2004) to discharge 0.12 MGD process wastewater via Outfall 001 to Bagg Brook, a tributary to the Connecticut River. The facility is engaged in the manufacturing of heavy cream, condensed milk, nonfat dry milk, and butter. The discharge is from process condensate water.		
PERMITTEE Town of Amherst	NPDES # MAG640046	SEGMENT Tributary to MA34-35
The Town of Amherst is authorized (MAG640046 issued January 2001) to discharge 0.048 MGD (average monthly and daily maximum) of effluent from the Centennial Water Treatment Plant to Harris Brook (mistakenly identified as Amethyst Brook in the permit). The total residual chlorine (TRC) limit is 0.74 mg/L average monthly and 1.0 mg/L daily maximum. One modified acute and chronic whole effluent toxicity test using <i>C. dubia</i> was required and conducted in June 2001. No acute toxicity was detected but the CNOEC result was 50% effluent. Survival of <i>C. dubia</i> exposed (7-day) to water collected from Harris Brook just downstream from the intake reservoir on Harris Brook was 100%. Hardness of the river water was 10 mg/L.		
PERMITTEE Town of Amherst	NPDES # MA0100218	SEGMENT MA34-04
The Town of Amherst is authorized (MA0100218 issued in September 2006) to discharge from the Amherst Wastewater Treatment Plant a flow of 7.1 MGD (average monthly) of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit is 1.00 mg/L (daily maximum) between 1 April and 31 October. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and June 2007 ranged from <0.075 to 29 mg/L (n=11) while TRC concentrations ranged from <0.02 to 0.09 mg/L (n=12).		
PERMITTEE Australis Aquaculture, LLC	NPDES # MA0110264	SEGMENT MA34-02
Australis Aquaculture, LLC is authorized (MA0110264 issued in September 2003) to discharge from the facility at 15 Industrial Boulevard in Turner Falls an average monthly and daily maximum flow of 0.3 MGD of treated effluent from the indoor farming facility currently for <i>Australis barramundi</i> via Outfall #001 to the Deep Hole of the Connecticut River (until relocation and termination of the discharge, or expiration of the permit). (This permit was formerly issued to Mass Fin Tech, LLC and prior to that Aqua Partners Technologies, LLC). The TRC limit is 0.01 mg/L average monthly and 0.019 mg/L daily maximum. The total phosphorus limit is 0.2 mg/L average monthly. The permit also authorizes this discharge via Outfall #002 to the Connecticut River (following relocation and the termination of the discharge from "Deep Hole").		
PERMITTEE Town of Belchertown Department of Public Works	NPDES # MA0102148	SEGMENT MA34-06
The Town of Belchertown Department of Public Works is authorized (MA0102148 issued in December 2005) to discharge from the Belchertown Water Reclamation Facility a flow of 1.0 MGD average monthly of treated effluent via Outfall #001 to Lampson Brook. The facility's whole effluent toxicity limits are $LC_{50} \geq 100\%$ and C-NOEC $\geq 94\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis. The total phosphorus limit is 0.25 mg/L average monthly. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and August 2007 ranged from <0.01 to 1.70 mg/L (n=32). Total Residual Chlorine (TRC) concentrations reported during the same time period were <0.05 mg/L (n=32).		
PERMITTEE Berkshire Electric Cable Co.	NPDES # MA0032832	SEGMENT MA34-28
Berkshire Electric Cable Co. is authorized to discharge contact and non-contact cooling water from their facility in Leeds 0.017MGD (daily maximum) via Outfall #001 into a swamp area adjacent to the Mill River.. Stormwater flows into Fire Pond, which is also adjacent to the Mill River. It should be noted that Berkshire installed a closed loop contact cooling water system so that it no longer discharges industrial wastewater according to a letter received June 2007. The TRC concentration reported in the whole effluent toxicity report in June 2004 was <0.05 mg/L (n=1).		

PERMITTEE Bioshelters, Inc.	NPDES # MA0110281	SEGMENT Tributary to MA34-25
Bioshelters, Inc. is authorized (MA0110281 issued in December 2002) to discharge from their facility in Amherst a maximum daily flow of 0.0864 MGD of fish culture effluent via Outfall #001 to Great Swamp to an unnamed tributary of the Mill River Hadley. The facility is engaged in farming of Tilapia (capacity to produce 6000,000 lbs annually). The facility raises fish and hydroponic produce in a recirculation aquaculture and hydroponic system. The wastewater from the fish is used to grow plants, and plants are used to clean the water for the fish. Water is supplied to the facility by an on-site well.		

PERMITTEE Boston and Maine Corporation	NPDES # MA0000272	SEGMENT Tributary to MA34-04
Boston and Maine Corporation (B&M) is authorized to discharge from the East Deerfield Rail Yard facility (NPDES # MA0000272 issued September 2005 and modified with an effective date of 1 July 2006) for the discharge of stormwater and process wastewater treated by a Dissolved Air Flotation system via Outfall #004 to an unnamed brook to the Connecticut River. The flow limit is 0.015 MGD average monthly and 0.045 MGD daily maximum. The facility is required to submit the results of modified acute and chronic whole effluent toxicity tests conducted once a year in March with both <i>C. dubia</i> and <i>P. promelas</i> on grab samples of the discharge. No acute whole effluent toxicity was detected by either test species in March 2006 or 2007 (i.e., $LC_{50} > 100\%$ effluent). Some chronic toxicity was detected (CNOEC = 50% effluent to <i>P. promelas</i> in 2006 and CNOEC = 50% effluent to <i>C. dubia</i> in 2007). Survival of both test organisms exposed to river water collected in the unnamed tributary downstream from the 004 discharge was $\geq 80\%$. Dilution water sampling location will be corrected to a site upstream from the discharge in subsequent whole effluent toxicity tests. A Stormwater Pollution Prevention Plan (SWPPP) that includes monitoring requirements is also an integral part of this permit.		

PERMITTEE Chang Farms, Inc.	NPDES # MA0040207	SEGMENT MA34-04
Chang Farms, Inc. is authorized (MA0040207 issued in September 2006) to discharge from their facility in Whately a monthly average flow of 0.15 MGD of treated effluent via Outfall #001 to the Connecticut River. The farm is an agricultural enterprise that produces bean sprouts in different varieties for the retail market. Water is drawn from an on-site wellfield for irrigation (including sprout soaking), washing sprout plants, and equipment cleaning. On average 0.12 MGD is used to irrigate and wash/rinse harvested plants and an average of 0.03 MGD is used to clean and sanitize process equipment. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit is 1.0mg/L (monthly average and daily maximum) year round. The permit authorizes this discharge via Outfall 002 to Sugarloaf Brook, a tributary to the Connecticut River, until the direct discharge to the river via Outfall 001 is completed. The permittee agreed to install a UV disinfection system to treat coliform bacteria in the effluent. The TRC monitoring is required because of cleaning products.		

PERMITTEE City of Chicopee	NPDES # MA0101508	SEGMENT MA34-05
<p>The City of Chicopee is authorized (MA0101508 issued in May 2005) to discharge from the Chicopee Water Pollution Control Facility an average monthly flow of 15.5 MGD of treatment plant effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 100\%$ effluent using <i>P. promelas</i> as a test species on a quarterly basis. The TRC limit between 1 April and 31 October is 0.89 and 1.0 mg/L (average monthly and daily maximum limits, respectively). Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from 0.04 to 24mg/L (n=31) (note most measurements were >10 mg/L) while TRC concentrations ranged from <0.05 to 2.2 mg/L (n=32) although there was only one reported exceedance of the TRC limit. It should also be noted that construction was completed for the facility's "Secondary Bypass Disinfection Facility" in mid 2006. The permit also authorizes the discharge of stormwater/wastewater via combined sewer overflows during wet weather via nine outfalls to the Connecticut River as follows:</p> <ul style="list-style-type: none"> 001 Britton Street in front of house #171 (30" pipe). Fairview sewer separation (32 Million Gallons/Year) in construction to be completed in 2009. 003 Power line right of way south of James Street (30" pipe) 004 Riverview Place Sewage Pumping Station (21" pipe) 005 Leslie Street Sewage Pumping Station (36" pipe) 006 Call Street Sewage Pumping Station (60" pipe) 007-I Jones Ferry Road Sewage Pumping Station (70X69 rectangle). Major project in construction to be completed in 2009 - 173 Million Gallons/Year. 007-II Jones Ferry Road Sewage Pumping Station (36" pipe) 008 Easement south of Jones Ferry Road Sewage (48" pipe) 009 Paderewski Street Sewage Pumping Station (60" pipe). This discharge was eliminated in late 2006. 		

PERMITTEE Commonwealth of Massachusetts Division of Fisheries and Wildlife	NPDES # MA0110035	SEGMENT Tributary to MA34-04
The Massachusetts Division of Fisheries and Wildlife is authorized (MA0110035 issued in September 2007) to discharge from the Sunderland State Fish Hatchery a flow of 1.17 MGD average monthly and 1.68 daily maximum of treated effluent via Outfall #001 to Russellville Brook, a tributary to the Connecticut River. The facility's whole effluent toxicity limits are $LC_{50} \geq 100\%$ and $C\text{-NOEC} \geq 100\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis when formalin is used. These monitoring requirements were also a condition of the prior permit. The facility has reportedly not used formalin since 1993, so they have not conducted any whole effluent toxicity tests.		

PERMITTEE Commonwealth of Massachusetts Division of Fisheries and Wildlife	NPDES # MA0110051	SEGMENT Tributary to MA34-04
The Massachusetts Division of Fisheries and Wildlife is authorized (MA0110051 issued in December 2001) to discharge from the Montague (Bitzer) State Fish Hatchery a flow of 1.4 MGD average monthly and 1.55 daily maximum of treated effluent via Outfall #001 to an unnamed tributary of the Connecticut River. The facility's whole effluent toxicity limits are $LC_{50} \geq 100\%$ and $C\text{-NOEC} \geq 100\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis when formalin is used. The facility has reportedly not used formalin for the last 15 years, so they have not conducted any whole effluent toxicity tests.		

PERMITTEE Consolidated Edison Energy of Massachusetts, Inc. (CEEMI)	NPDES # MA0004707	SEGMENT MA34-05
<p>CEEMI is authorized (MA0004707 issued in November 2004) to discharge the following from the West Springfield Station (coal/oil fired power plant) to the Connecticut River:</p> <p>Outfall #001: 1.1 MGD daily maximum of once through cooling water for the two combustion turbine generator (CTG) unit's lube oil cooling systems combined with the CTG's sandfilter backwash water. The maximum daily temperature shall not exceed 91°F, and the temperature rise from the inlet shall not exceed 20°F.</p> <p>Outfall #002A: 69 MGD of once through condenser cooling water for Unit 3 steam turbine generator combined with Unit 3's sandfilter backwash water and the hydrogen booster pumps cooling water from 15 April to 31 October. The maximum daily temperature shall not exceed 112°F, and the temperature rise from the inlet shall not exceed 37°F. The TRC limit is 0.13 and 0.2 mg/L (average monthly and daily maximum, respectively during chlorination events).</p> <p>Outfall #002B: 69 MGD of once through condenser cooling water for Unit 3 steam turbine generator combined with Unit 3's sandfilter backwash water and the hydrogen booster pumps cooling water from 1 November to 14 April. The maximum daily temperature shall not exceed 100°F, and the temperature rise from the inlet shall not exceed 48°F. The TRC limit is 0.13 and 0.2 mg/L (average monthly and daily maximum, respectively during chlorination events).</p> <p>Outfall #005: intake screen wash.</p> <p>Outfall #006: stormwater from electric control room roof drains and yard areas (including parking lot,</p> <p>Outfall #010: CTG's sandfilter backwash water, and</p> <p>Outfall #020: Unit 3's sandfilter backwash water.</p> <p>Annual reports must be submitted detailing hourly intake and discharge temperature monitoring, net heat load, amount of water discharged. Biological and thermal monitoring studies to evaluate the effects of West Springfield Station's discharge on the balanced, indigenous population of shellfish, fish and wildlife in an on the Connecticut River and the effectiveness of location, design, construction, and capacity of the cooling water intake structure to minimize adverse environmental effects are also required. Ichthyoplankton (fish eggs and larvae) occurrence and abundance of species entrained and in a transect of the Connecticut River upstream from the Station, and finfish occurrence and abundance of species impinged</p>		

PERMITTEE Town of Deerfield	NPDES # MA0101648	SEGMENT MA34-04
<p>The Town of Deerfield is authorized (MA0101648 issued in January 2007) to discharge from the South Deerfield Wastewater Treatment Plant a flow of 0.85 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L (daily maximum). (These same limits and monitoring requirements were in the August 2000 permit.)</p> <p>Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from <0.1 to 9.6 mg/L while TRC concentrations were all <0.050 mg/L (n=16).</p>		

PERMITTEE Town of Easthampton	NPDES # MA0101478	SEGMENT MA34-04
<p>The Town of Easthampton is authorized (MA0101478 issued in September 2007) to discharge from the Easthampton Wastewater Treatment Plant (WWTP) a flow of 3.8 MGD average monthly of treated sanitary and industrial wastewater via Outfall #001 and #002 to the Connecticut River and the Manhan River, respectively. In the recently issued permit the facility's whole effluent toxicity limits are as follows:</p> <p>Outfall 001: $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> in June and September. The TRC limit between 1 April and 30</p>		

November is 1.0 mg/L (average monthly and daily maximum).

Outfall 002: $LC_{50} \geq 100\%$ effluent and CNOEC report only using *C. dubia* in March and December. The TRC limit between 1 April and 30 November is 0.05 mg/L (average monthly and daily maximum).

Ammonia-nitrogen concentrations reported for Outfall 001 in the whole effluent toxicity reports submitted between June 2000 and December 2006 ranged from 0.462 to 19mg/L (n=15), while TRC concentrations were ≤ 0.32 mg/L (n=15). According to the fact sheet of the NPDES permit "The main effluent pipe is approximately 2.1 miles long and discharges to the Connecticut River by gravity. The outfall is located near shore, just downstream of the confluence of the Connecticut and Manhan Rivers. During periods when discharge flows exceed the capacity of Outfall #001, flow is discharged to the Manhan River through Outfall #002. The hydraulic capacity of Outfall #001 varies based on the hydraulic regime in the Connecticut River. For example, the permittee estimates that the peak capacity is 3.1 MGD at normal river level (101 ft.), 2.7 MGD at the ten-year flood level and 1.2 MGD at the 50-year flood level (124 ft.)...during the summer months with no discharges from Outfall #002, the maximum daily flows (as opposed to the peak capacities listed above), as measured by the plant's influent flow meter, are about 2 MGD, indicating that the maximum daily flow capacity of Outfall #001 at normal river stage is about 2 MGD".

PERMITTEE FirstLight Hydro Generating Company	NPDES # MA0035521	SEGMENT MA34-03
Cabot Station (hydropower project): The FirstLight Hydro Generating Company (formerly the NE Hydro Generating Company and the Northeast Generation Company (NGC) is authorized (MA0035521 issued in September 1996) to discharge from the Cabot Station, sump pump discharge via Outfall #001; groundwater drain pipe discharge via Outfall #002; transformer cooling pit discharge via Outfall #003; six pit drain discharge via Outfall #004; three floor drain discharge via Outfall #005; two sump discharges via Outfall #006; and generator water seal leakage via Outfall #007 to the Connecticut River.		

PERMITTEE FirstLight Hydro Generating Company	NPDES # MA0035530	SEGMENT MA34-02
Northfield Mountain Station (a pump storage hydropower project): The FirstLight Hydro Generating Company (formerly the NE Hydro Generating Company and the Northeast Generation Company - NGC) is authorized (MA0035530 issued in September 1996) to discharge the following from the Northfield Mountain Station to the Connecticut River: Outfall #001: floor and associated drain water; Outfall #002: non-contact cooling water in heat exchanger for transformer, bearing cooling, liquid rheostat cooling, oil coolers, and generator coolers.		

PERMITTEE Town of Hadley	NPDES # MA0100099	SEGMENT MA34-04
The Town of Hadley is authorized (MA0100099 issued in April 2006) to discharge from the Hadley Wastewater Treatment Plant (WWTP) a flow of 0.54 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's acute whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L daily maximum. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and June 2006 ranged from <0.1 to 13 mg/L (n=12) while TRC concentrations were all <0.05 mg/L (n=12).		

PERMITTEE Hampden Papers, Inc.	NPDES # MAG250881	SEGMENT MA34-05
Hampden Papers, Inc. is authorized (MAG250881 issued September 2000) to discharge 0.22 MGD (maximum daily) of non-contact cooling water via Outfalls 002 and 003 to the Connecticut River. The facility reports the maximum daily temperature doesn't exceed 79°C while pH is in the range of 7.3 to 7.9 SU. The source of water for the facility is municipal. TRC concentrations in the discharge ranged from 0.24 to 1.0 mg/L according to DMRs submitted in 2007.		

PERMITTEE Town of Hatfield	NPDES # MA0101290	SEGMENT MA34-04
The Town of Hatfield is authorized (MA0101290 issued in April 2006) to discharge from the Hatfield Wastewater Treatment Plant a flow of 0.5 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L (daily maximum). Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between May 2001 and October 2006 ranged from 5.2 to 45 mg/L (n=12) while TRC concentrations ranged from 0.01 to 0.42 mg/L (n=12).		

PERMITTEE Hazen Paper Company	NPDES # MAG250872	SEGMENT MA34-05
Hazen Paper Company is authorized (MAG250872 issued September 2000) to discharge an average monthly flow of 0.258 MGD of non-contact cooling water via Outfall #001 and 0.09 MGD of non-contact cooling water via Outfall #002 to the Connecticut River. The facility DMR reports for 2007 that the maximum daily temperature didn't exceed 71.2°C while pH was in the range of 7.5 to 7.9 SU. The source of water for the facility is four private wells.		

PERMITTEE Hercules, Inc.	NPDES # MAG250848	SEGMENT MA34-05
Hercules, Inc. is authorized (MAG250848 issued in January 2001) to discharge 0.2 MGD (maximum daily) of non-contact cooling water to the Connecticut River via Outfall 001. The facility reports the maximum daily temperature doesn't exceed 77°C while pH is in the range of 7.1 to 8.2 SU. The source of water for the facility is municipal. TRC concentrations in the discharge ranged from 0.49 to 0.56 mg/L according to DMRs submitted in 2007.		

PERMITTEE City of Holyoke	NPDES # MA0101630	SEGMENT MA34-05, MA34-04
<p>The City of Holyoke is authorized (MA0101630 issued in September 2000) to discharge treated effluent from the Holyoke Department of Public Works an average monthly flow of 17.5 MGD via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 100\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis. The TRC limit between 1 April and 31 October 31 is 0.74 and 1.00 mg/L (average monthly and daily maximum, respectively). Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from 1.13 to 12.7 mg/L (n=29).</p> <p>The permit also authorizes the discharge of stormwater/wastewater via combined sewer overflows during wet weather into the Connecticut River and the Holyoke Canal as described below:</p> <p>Connecticut River upstream from the Holyoke Dam (Segment MA34-04)</p> <p>Outfall 021: River Terrace. Note this discharge reduced to 28 Million Gallons/year from 58 MGY by the Green Brook Separation Project completed late 2001/early 2002.</p> <p>Outfall 020: Cleveland Street.</p> <p>Outfall 023: Jefferson Street to a "dingle" at this site, which doesn't appear to reach the Connecticut River.</p> <p>Outfall 019: Yale Street.</p> <p>Outfall 018: Walnut Street</p> <p>Combined sewer overflows to the Connecticut River downstream from the Holyoke Dam (Segment MA34-05)</p> <p>Outfall 014: Mosher Street. Note this outfall was eliminated in 2005. The Mosher Street Sewer Separation Project eliminated an estimated 31 Million Gallons/year.</p> <p>Outfall 013: Appleton Street.</p> <p>Outfall 011: Jackson Street</p> <p>Outfall 009: Berkshire Street. The Berkshire Street Screening and Disinfection Facility Project was completed in October 2007 (treating an estimated 270 Million Gallons/year).</p> <p>Outfall 008: Springdale Park.</p> <p>Outfall 007: Northampton Street/Glen Street.</p> <p>Outfall 003: Jones Ferry Road</p> <p>Outfall 002: Providence Hospital</p> <p>Combined sewer overflows to the Holyoke Canal:</p> <p>Outfall 016: Front Street/Appleton Street - First Level Canal</p>		

PERMITTEE Holyoke Gas and Electric Department (HG&E)	NPDES # MA0001520, MA0035866, MA0035882, MA0035874, MA0035564	SEGMENT Holyoke Canal System to MA34-05
<p>The Holyoke Gas & Electric Department (HG&E) is authorized (MA0001520 issued in December 2005) to discharge the following from the Cabot Street Station (gas/oil fired power plant) to the Holyoke Canal System:</p> <p>Outfall #001 - 10.8 MGD average monthly and 23.0 MGD daily maximum of condenser cooling water from Units 6, 8, and 9, the maximum daily temperature shall not exceed 102°F, and the temperature rise from the inlet shall not exceed 30°F. The permit also requires that a modified acute and chronic whole effluent toxicity test be conducted once during the permit cycle using both <i>C. dubia</i> and <i>P. promelas</i> as test species. The facility operates a full depth fish excluder system (FES) located near the headgates of the canal system to minimize impacts from the cooling water intake structure (CWIS). The permit also requires rotation and inspection of the CWIS intake screens and reports to the Department in the event of a fish kill/impingement event. Thermal sampling in the canal and Connecticut River in July/August during a four-hour period of electricity production on one day was also required.</p> <p>Outfall #002 – 0.025 MGD average monthly (0.1 MGD daily maximum) of neutralization tank wastewater.</p> <p>The permit also authorizes the discharge of two internal outfalls (004 and 005) to outfalls 001 and/04 002.</p> <p>HG&E is also authorized (MA0035564, MA0035882, MA0035866, and MA0035874 issued September 1996) to discharge from four stations (hydropower projects) to the Holyoke Canal. These permits were transferred to HG&E from Holyoke Water Power Company in December 2001.</p> <p><u>Riverside Station:</u> Outfall #001 bearing cooling water, Outfall #002 flood water pump, Outfall #004 sump pump, and Outfall #005 bearing cooling water for Unit 7.</p> <p><u>Hadley Falls Station:</u> Outfall #002 generator cooler for Unit 1, Outfall #003 thrust bearing oil cooler, Outfall #004 wheel pit sump, Outfall #005 station service pump for Unit 1, Outfall #006 dewatering sump, Outfall #007 wheel pit sump with oil/water separator, and Outfall #008 generator cooler for Unit 2.</p> <p><u>Chemical Station:</u> Outfall #001 turbine bearing cooling water.</p> <p><u>Boatlock Station:</u> Outfall #001 bearing cooling water, and Outfall #002 thrust bearing cooling water.</p> <p>Note: there are two additional stations, Skinner and Beebe-Holbrook, with unpermitted waterwheels prior to the Riverside Station which should be permitted.</p>		

PERMITTEE Intelicoat Technologies, LLC	NPDES # MAG250968	SEGMENT MA34-05
Intelicoat Technologies, LLC in South Hadley is authorized (MAG250968 issued June 2001 formerly permitted to Rexam Image Products) to discharge 0.082 MGD average monthly of non-contact cooling water to Buttery Brook. The source of water for the facility is the Water Department Fire District 1. The facility conducted modified acute and chronic toxicity tests on two flow weighted composite samples of their ten outfalls (reported as Outfall 001 "upstream" and Outfall 002 "downstream"). No acute or chronic toxicity to <i>C. dubia</i> was detected in the tests conducted in July 2001. Survival of <i>C. dubia</i> exposed (7-day) to water collected from Buttery Brook was 100%.		

PERMITTEE JP Elastomerics Corporation	NPDES # MA0001503	SEGMENT MA34-15
JPS Elastomerics – Stevens Urethane, Hampshire Plant MA0001503 issued September 2004 for the discharge of contact and non-contact cooling water via Outfall #001 a wetland to Wilton Brook. The flow limit is 0.020 MGD daily maximum. The facility was required to conduct a whole effluent toxicity test in September (limits are $LC_{50} \geq 100\%$ and $C\text{-NOEC} \geq 100\%$ effluent) using <i>C. dubia</i> as a test species. The TRC limit is 0.011 mg/L average monthly and 0.019 mg/L daily maximum.		

PERMITTEE Town of Montague	NPDES # MA0100137	SEGMENT MA34-04, MA34-03
The Town of Montague is authorized (MA0100137 issued in November 2000) to discharge from the Montague Water Pollution Control Facility a flow of 1.83 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis. The TRC limit between April 1 and October 31 is 1.0 mg/L daily maximum. The maximum TRC measurement reported in the whole effluent toxicity reports between August 2000 and September 2006 was 0.15 mg/L (n=15). Ammonia-nitrogen concentrations in the effluent during this time ranged from 0.16 to 2.9 mg/L (n=15). The facility also has two regulators that remain. Outfall #01 is located near Greenfield Road. Outfall #02 reportedly discharges to the Connecticut River Segment MA34-03 and receives overflows from two regulator structures located in Avenue A and at 7 th and L Streets in Turners Falls. A long-term CSO control plan was approved in March 2005. Work should be completed by the end of 2008 which will reduce or eliminate the CSO discharges.		

PERMITTEE Mt. Tom Generating Company, LLC	NPDES # MA0005339	SEGMENT MA34-04
<p>The Mt. Tom Generating Company, LLC is authorized (MA0005339 issued in September 1992) (formerly permitted to the Holyoke Water Power Company prior to 1 November 2006) to discharge the following to the Connecticut River from the Mt. Tom Station (coal fired power plant):</p> <p>Outfall #001 - 133.2 MGD average monthly/daily maximum for two pump operation, or 70.0 MGD average monthly/ daily maximum for one pump operation of once through cooling water with a maximum total residual oxidant (TRO) of 0.15 mg/L (both chlorine and bromine are used for biofouling) when in use, and a maximum temperature of 39°C(102°F). The temperature rise from the inlet during two pump operation shall not exceed 11.1°C(20°F) and during one pump operation shall not exceed 17.7°C(32°F).</p> <p>Outfall #002 - 0.216 MGD average monthly (0.36 MGD daily maximum) of wastewater treatment plant effluent;</p> <p>Outfalls #003, 004, 007, and 009A – stormwater runoff;</p> <p>Outfall #005 - 0.71 MGD (normal) daily maximum or 1.074 MGD (with intermittent fire pump uses) daily maximum of screen wash and service water tank overflow;</p> <p>Outfall #006 - 0.144 MGD daily maximum reflecting pool overflow;</p> <p>Outfalls #008 and #009 – 0.25 MGD average monthly (0.30 MGD daily maximum) bottom ash transport water;</p> <p>Outfalls #010 and #011 - 1.0 MGD average monthly (1.2 MGD daily maximum) fly ash transport water</p> <p>No biological monitoring was required in the permit other than to report any unusual numbers (twice the average) of fish impinged on the intake.</p>		

PERMITTEE City of Northampton	NPDES # MA0101818	SEGMENT MA34-04
The City of Northampton is authorized (MA0101818 issued in May 2002) to discharge from the Northampton Wastewater Treatment Plant a flow of 8.6 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River and #002 to the Mill River bed when the Connecticut River is in high flow stage. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L average monthly and daily maximum. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between November 2000 and September 2007 ranged from 0.81 to 23 mg/L (n=15) while TRC concentrations ranged from <0.02 to 0.39 mg/L (n=14).		

PERMITTEE City of Northampton	NPDES # MAG640034	SEGMENT MA34056
The City of Northampton is authorized (MAG640034 issued in May 2003) to discharge from the Northampton Water Treatment Facility 0.82 MGD average monthly of treated filter backwash water as supernate overflow from settling lagoons into Mountain Street Reservoir. This facility was supposed to go on-line in August 2005.		

PERMITTEE Town of Northfield	NPDES # MA0100200	SEGMENT MA34-01
The Town of Northfield is authorized (MA0100200 issued in May 2002) to discharge from the Town of Northfield Wastewater Treatment Facility a flow of 0.275 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis (testing required in May and August each year). The Total Residual Chlorine (TRC) limit between 1 April and 31 October is 1.0 mg/L (both average monthly and daily maximum). Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and August 2007 ranged from <0.100 mg/L to 21.400 mg/L (n=15). TRC concentrations reported in the whole effluent toxicity reports between August 2000 and August 2007 are <0.050 mg/L to 0.360 mg/L (n=15).		

PERMITTEE Northfield Mount Hermon School	NPDES # MA0032573	SEGMENT MA34-02
The Northfield Mount Hermon School is authorized (MA0032573 issued in September 2005) to discharge from their facility in Gill a flow of 0.45 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on an annual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L average monthly and daily maximum. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from 0.47 to 21mg/L (n=14) while TRC concentrations ranged from 0.02 to 0.42 mg/L (n=14).		

PERMITTEE Omniglow Corporation	NPDES # MAG250010	SEGMENT MA34-05
Omniglow Corporation of West Springfield is authorized (MAG250010 issued February 2001) to discharge 500 gallons per day of non-contact cooling water to the Connecticut River. The source of water for the facility is municipal.		

PERMITTEE Pro Corporation - PMC	NPDES # MAG250741	SEGMENT MA34-28
Pro Corporation – PMC of Florence is authorized (MAG250741 issued November 2002) to discharge 0.108 MGD of non-contact cooling water to Mill River - Northampton. The source of water for the facility is municipal.		

PERMITTEE Raytor Compounds, Inc.	NPDES # MAG250960	SEGMENT MA34-28
Raytor Compounds, Inc. (formerly Perstorp Compounds, Inc.) in Florence is authorized (NPDES permit #MAG250960 issued January 2006) to discharge 0.05 MGD (daily maximum) of non-contact cooling water to Mill River - Northampton. The source of water for the facility is municipal or an on-site well.		

PERMITTEE Red Wing Meadow Trout Hatchery	NPDES # MA0027880	SEGMENT MA34-41
The Red Wing Meadow Trout Hatchery was authorized (MA0027880 issued in April 2002) to discharge from the facility a flow of 1.44 MGD daily maximum of treated effluent via Outfall #001 to Sawmill River. The facility's whole effluent toxicity limits are $LC_{50} \geq 100\%$ and C-NOEC $\geq 50\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis when formalin is used. The limit for TRC is 0.022 and 0.038 mg/L (average monthly and daily maximum, respectively). According to EPA the permit was terminated in January 2005 because the facility went out of business.		

PERMITTEE South Deerfield Water Supply District	NPDES # MAG640005	SEGMENT Tributary to MA34-24
South Deerfield Water Supply District (MAG640005 issued April 2002) discharges approximately 0.04 MGD of effluent from the Roaring Brook Reservoir Water Treatment Facility to the Roaring Brook Reservoir outlet stream a tributary to the Mill River - Hatfield. Because of their low dilution factor, the facility was required to conduct a whole effluent toxicity test using <i>C. dubia</i> in September 2002.		

PERMITTEE Town of South Hadley	NPDES # MA0100455	SEGMENT MA34-05, MA34-19
<p>The Town of South Hadley is authorized (MA0100455 issued in June 2006) to discharge from the South Hadley Wastewater Treatment Plant (WWTP) a average monthly flow of 4.2 MGD of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>C. dubia</i> as a test species on a biannual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L average monthly and 1 daily maximum. The facility is also authorized to discharge stormwater/wastewater from combined sewer overflows during wet weather via Outfall 004 at Main Street South Hadley to the Connecticut River, from Outfall 010 at the Stonybrook Pump Station to Stony Brook (MA34-19), and via Outfall 012 at Gaylord Street to Buttery Brook. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from 0.45 to 31.7 mg/L (n=15) while TRC concentrations ranged from <0.02 to 0.28 mg/L (n=15).</p>		

PERMITTEE Southworth Company Turners Falls Mill	NPDES # MA0005011	SEGMENT MA34-03
<p>The Southworth Company Turner Falls Mill (formerly Esleek Manufacturing Company, Inc.) is authorized (MA0005011 issued in September 2007) to discharge from their Turner Falls Mill facility on Canal Street. The permit authorizes the discharge of treated process wastewater to the Turners Falls Power Canal via Outfall #001 and power generation water (pass through from the Turners Falls Power Canal) and non-contact cooling water via Outfall #002 to the Connecticut River. The new permit requires quarterly whole effluent toxicity testing ($LC_{50} \geq 50\%$ effluent limit) using <i>C. dubia</i> as a test species on the treated process wastewater discharge. The prior permit required testing three times per year with an $LC_{50} \geq 50\%$ effluent limit and a chronic report only requirement.</p> <p>Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between July 2000 and October 2007 ranged from <0.1 to 4.7 mg/L (n=25) while TRC concentrations ranged from 0.02 to 0.08 mg/L (n=26) with only one measurement >0.05 mg/L.</p> <p>The new permit requires that Best Technology Available for Cooling Water Intake Structure (CWIS) be implemented to minimize adverse environmental effects, all live fish and other aquatic organisms impinged, entrained, or trapped on or in the CWIS shall be returned to the power canal or Connecticut River by means to maximize their survival. Additionally, a CWIS Monitoring Program shall be implemented and an Annual CWIS Biological Monitoring Report shall be submitted to EPA and MassDEP.</p>		

PERMITTEE Springfield Water and Sewer Commission	NPDES # MA0101613	SEGMENT MA34-05
<p>The Springfield Water and Sewer Commission is authorized (MA0101613 issued in December 2000) to discharge an average monthly of 67 MGD of treated effluent from the Regional Waste Water Treatment Facility via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 100\%$ effluent using <i>C. dubia</i> as a test species on a quarterly basis. The TRC limit between 1 April and 31 October is 0.22 mg/L average monthly and 0.38 mg/L average weekly. Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from <0.1 to 2.8 mg/L (n=28).</p>		

PERMITTEE Springfield Water and Sewer Commission	NPDES # MA0103331	SEGMENT MA34-29/34-05
<p>The Springfield Water and Sewer Commission is authorized (MA0103331 issued in June 2003) to discharge from their facility, combined sewer overflow discharges to the following receiving waters:</p> <p>Connecticut River (MA34-05) outfalls:</p> <ul style="list-style-type: none"> #007 (Rowland Street), #008 (Washburn Street), #010 (Clinton Street), #011 (Liberty Street), #012 (Worthington Street), #013 (Bridge Street), #014 (Elm Street), #015 (Union Street), #016 (York Street), #018 (Longhill Street), and #049 (Springfield Street). <p>The North End sewer separation project (CSOs 007 and 049) to eliminate an estimated 65 Million Gallon/year is currently in the design phase and is anticipated to be completed in 2011.</p> <p>Mill River- Springfield (MA34-29) outfalls:</p> <ul style="list-style-type: none"> #017 (Fort Pleasant Ave. and Blake Hill), #019 (Mill, Orange, and Locust Streets), #024 (Rifle and Central Streets), #025 (Allen and Oakland Streets), #045 (Fort Pleasant Avenue), #046 (Belmont Street), and #048 (Allen and Rifle Streets). <p>Mill River Project completed in December 2003 eliminating an estimated 60 Million Gallons/Year.</p>		

PERMITTEE Town of Sunderland	NPDES # MA0101079	SEGMENT MA34-04
The Town of Sunderland is authorized (MA0101079 issued in June 2006) to discharge from the Sunderland Wastewater Treatment Plant (WWTP) a flow of 0.5 MGD average monthly of treated effluent via Outfall #001 to the Connecticut River. The facility's whole effluent toxicity limit is $LC_{50} \geq 50\%$ effluent using <i>Pimephales promelas</i> as a test species on a biannual basis. The TRC limit between 1 April and 31 October is 1.0 mg/L (daily maximum). Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and September 2007 ranged from 0.37 to 23mg/L (n=15) while TRC concentrations ranged from <0.05 to 0.6 mg/L (n=15).		

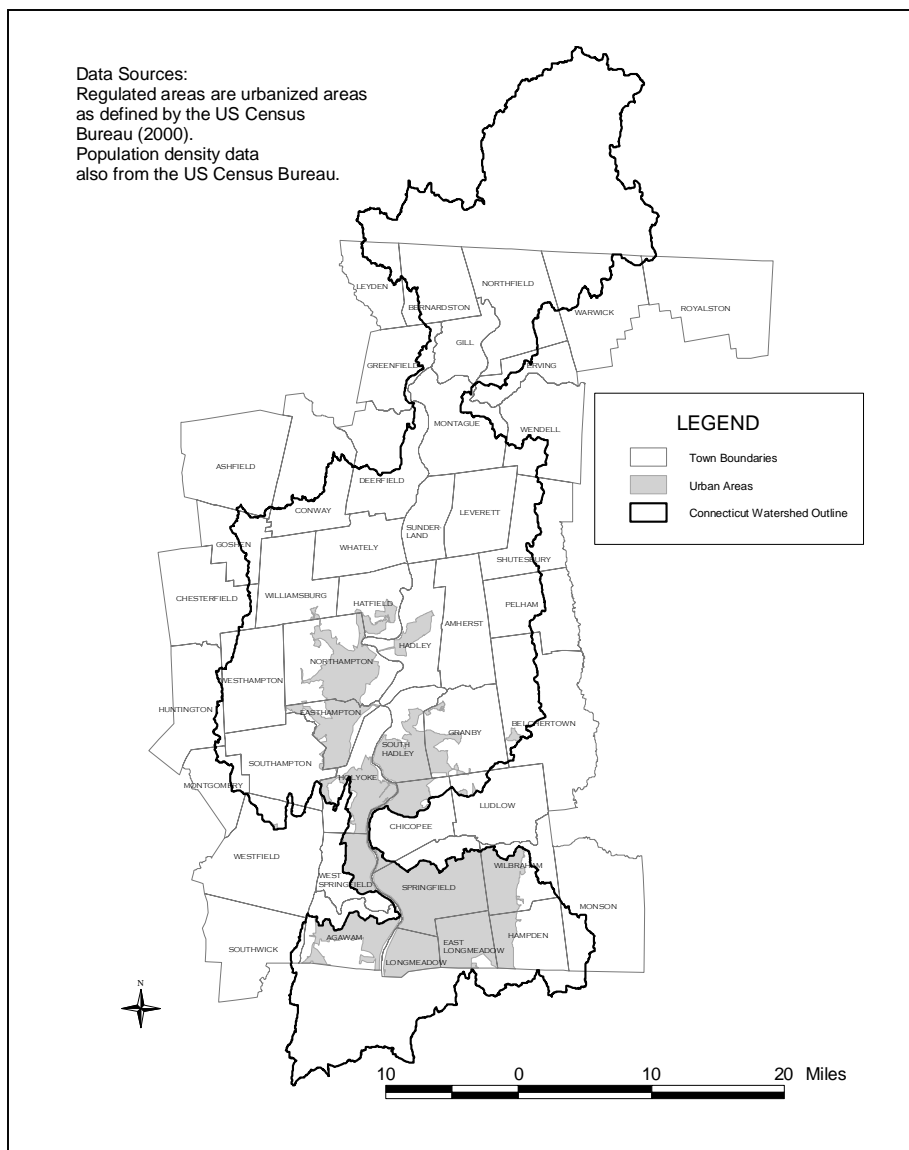
PERMITTEE University of Massachusetts	NPDES # MA0032689	SEGMENT Tributary to MA34-27
<p>The University of Massachusetts is authorized (MA0032689 issued in December 2003) to discharge from the Coal Storage and Handling Facility a flow of 50 GPM daily maximum of stormwater treatment of runoff from coal pile via Outfall #001 to Taylor Brook. The facility is required to update and implement their stormwater pollution prevention plan (SWPPP). Ammonia-nitrogen concentrations reported in the whole effluent toxicity reports between August 2000 and April 2005 ranged from <0.01 mg/L to 0.260 mg/L (n=15). TRC concentrations ranged from <0.020 to 0.12 mg/L (n=15), however only one measurement was above the minimum quantification level of 0.05 mg/L.</p> <p><u>Ambient</u></p> <p>The University of Massachusetts staff collected water approximately 100 yards above where the ditch runs into Taylor Brook, which flows into Fort River, for use as dilution water in the facility's whole effluent toxicity tests. Between August 2000 and April 2005, survival of <i>C. dubia</i> exposed (48 hours) to Taylor Brook ranged from 90 to 100% (n=15). Between August 2000 and April 2005, survival of <i>P. promelas</i> exposed (48 hours) to the Taylor Brook water ranged from 98 to 100% (n=15). Hardness ranged from 25 to 80mg/L (n=15).</p>		

STORMWATER

The NPDES Phase II General Permit program requires NPDES permit coverage for stormwater discharges from small municipal separate storm sewer systems (MS4s), and construction activity disturbing one acre or more of land in a mapped "urbanized area" defined and delineated by the US Bureau of Census in 2000

<http://www.epa.gov/npdes/pubs/fact2-2.pdf>. Large and medium MS4s (populations over 100,000) were permitted during Phase I of the NPDES stormwater program. Under EPA's Phase II Program, the definition of "municipal" includes Massachusetts communities, U.S. military installations, state or federal owned facilities such as

hospitals, prison complexes, state colleges or universities and state highways. An MS4 is a system that: discharges at one or more point sources; is a separate storm sewer system (not designed to carry combined stormwater and sanitary waste water); is operated by a public body; discharges to the Waters of the United States or to another MS4; and, is located in an "Urbanized Area". The NPDES Phase II General Permit requires operators of regulated MS4s to develop and implement a stormwater management program that prevents harmful pollutants from being washed or dumped directly into the storm sewer system which is subsequently discharged into local waterbodies. The NPDES Stormwater Phase II General Permit requires operators of regulated small municipal separate storm sewer systems (MS4s) to develop a stormwater management program that prevents harmful pollutants from being washed or dumped directly into the storm sewer system, and then discharged into local waterbodies. Certain Massachusetts communities were automatically designated (either in full or part) by the Phase II rule based on the urbanized area delineations from the 2000 U.S. Census.



As a result of the census mapping, 19 communities in the Connecticut River Watershed were located either totally or partially in the regulated Urbanized Area (see Table H5). All of these communities applied to EPA and MassDEP for coverage under the Phase II stormwater general permit, issued on 1 May 2003, with the exception of the Town of Williamsburg, which received a waiver of the Phase II stormwater requirements on May 16, 2003 since the area subject to jurisdiction has a population under 1,000 and otherwise satisfies the criteria identified at 40 CFR 123.35(d) 1. Municipalities that are totally regulated must implement the requirements of the Phase II permit in the entire town, while communities that are partially regulated need to comply with the Phase II permit only in the mapped Urbanized Areas. Phase II stormwater general permits will expire on 1 May 2008 (Domizio 2004). For detailed community maps see <http://www.epa.gov/region01/npdes/stormwater/ma.html>.

Table H5. NPDES Phase II stormwater permit information for the Connecticut River Watershed communities.

Community	Permit #	Permit Issued	Mapped Regulatory area in community
Agawam	MAR041001	8/22/2003	Partial
Belchertown	MAR041002	9/12/2003	Partial
Chicopee	MAR041003	9/4/2003	Partial
EastLongmeadow	MAR041005	10/16/2003	Partial
Easthampton	MAR041110	9/12/2003	Partial
Granby	MAR041007	10/2/2003	Partial
Hadley	MAR041008	9/3/2003	Partial
Hampden	MAR041009	9/12/2003	Partial
Hatfield	MAR041010	9/15/2003	Partial
Holyoke	MAR041011	10/2/2003	Partial
Longmeadow	MAR041013	10/31/2003	Total
Ludlow	MAR041014	10/16/2003	Partial
Northampton	MAR041016	9/12/2003	Partial
South Hadley	MAR041020	9/19/2003	Partial
Southampton	MAR041021	10/3/2003	Partial
Springfield	MAR041023	9/12/2003	Total
West Springfield	MAR041024	9/18/2003	Total
Wilbraham	MAR041025	10/7/2003	Partial
Williamsburg	waiver10		

Information about other general stormwater NPDES permittees are available online at:
<http://cfpub.epa.gov/npdes/stormwater/noi/noisearch.cfm>.

LITERATURE CITED

Domizio, L. 2004. *Stormwater permitting information Phase II Communities*. Massachusetts Department of Environmental Protection, Division of Watershed Management, Worcester, MA. Personal Communication.

Appendix I

The Former Holyoke Gas Works & The Holyoke Gas Tar Deposits

Project Summary Written by Lisa Jones, Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup December 2007

The Gas Works in Holyoke manufactured combustible gas from coal and oil for residential, commercial, and industrial heating and lighting from 1852 to 1951. The former Gas Works once occupied a 2-acre peninsula on the Connecticut River 1500 feet downstream of the Holyoke Dam. Historic operations resulted in large releases of tar and oil to soil, groundwater, sediment, and surface water. Assessment and cleanup are required under the Massachusetts Contingency Plan. The potentially responsible parties (PRPs), conducting the cleanup work, are the former owner/operators of the facility: Holyoke Water Power Company (HWP), owner/operator from 1852-1902, Holyoke Gas & Electric Department (HG&E), owner/operator from 1902-1952, and the City of Holyoke. Northeast Utilities Service Company, agent for HWP, is conducting the cleanup of tar deposits in the river (RTN 1-1055), and HG&E is conducting the cleanup of the upland area and the No.2 Raceway (RTN 1-816). Massachusetts Department of Environmental Protection (MassDEP) site management oversees the work. As of December 2007, approximately \$20 million dollars has been spent on assessment and remediation at the two sites. The future costs are unknown.

The Gas Works utilized two types of manufacturing processes: coal carbonization and the carbureted water-gas (CWG) process. Each process generated tar as a by-product, namely coal tar and carbureted water-gas tar. According to records research and calculations performed by MassDEP, this manufactured gas plant ("MGP") produced approximately ten million gallons of MGP tar during its 100 years of operations. (The term "MGP tar" refers to both coal tar and carbureted water-gas tar since it is not necessary to distinguish between the two.)

Holyoke Gas Tar Deposits (River) – RTN 1-1055

While MGP tar was typically a valuable resource that could be sold or used by a gas works, tar was often released to the environment via spills, leaks, and direct surface water discharges. In the early years of the industry, excess tar was typically disposed or discarded into nearby water bodies since uses for tar, other than as fuel, had not yet been developed. As the industry progressed, MGP tar was less likely to be discarded however tar/ water emulsions produced by the CWG process became problematic: when an emulsion would not properly separate, it was usually discarded.

An 1898 plan of the Holyoke Gas Works shows that the facility was initially equipped with a piping system that enabled direct discharges of tar into the Connecticut River to the north and into the No. 2 Overflow Raceway ("Raceway") to the south. Additional site plans from the 1930s and 1940s show the presence of overflow and drain pipes originating from underground tar storage areas (tar wells), extending through the flood wall, and emptying into the river and Raceway. Tar inventory records of Holyoke Gas Works for the period between 1903 and 1952 revealed that 126,000 gallons of MGP tar and 124,000 gallons of gas-making oil were "lost" to the river during floods, reconstruction of the floodwall, and unexplained incidents. Tar and oil losses from prior years, 1852-1902, are presumed to have occurred but detailed bookkeeping records were

not found. Some large, one-time events occurred such as the loss of 30,000 gallons of tar and 87,000 gallons of gas oil lost in the 1936 flood, and 38,000 gallons of oil lost in the 1938 flood and hurricane.

Gas oil and tar emulsions released to the river may have floated or been suspended, but tar usually sank in waterways. The tar settled over very large areas of the Connecticut River within the 2.7-mile stretch between the Route 116 bridge in South Hadley Falls and the south end of Springdale Park in Holyoke. Visible tar deposits, observed by divers, occupy around 3 acres, and submerged tar areas may occupy another 20 to 30 acres. Tar thickness varies from 2 inches to 3 feet. Overlying substrates vary in composition- sand, silt, gravel, and cobbles, and the thickness of material covering tar deposits ranges from zero to 3.5 feet. Exposed areas are noted to silt over during summer and support caddis fly larvae. The topside of tar deposits is sometimes hardened like a rind, while underneath it can be sticky or friable. Softer tar deposits were observed to release liquid blebs on occasion and soft tar reportedly fouls the diver's tools. Tar hardness changes with water temperatures and UV influence.

The tar deposits exist in an area known to provide spawning habitat for the federally endangered short-nose sturgeon (*Acipenser brevirostrum*). Tar deposits also coexist in habitat for two state-protected mussel species and numerous finfish and shellfish. Human health exposures may occur through recreational activities taking place in and along the river. Under the presumption that tar deposits pose readily apparent harm and substantial environmental hazard, MassDEP required remediation of the tar deposits. HWP signed a consent order to complete the actions required by MassDEP. HWP also settled with federal and State natural resource trustees on a claim for injured resources.

Removal of tar deposits performed in 2002-2006 resulted in the removal and disposal of 11,714 yd³ of tar and tarry sediment. The removal was accomplished using mechanical excavation in dry (dewatered) areas and in wet excavations where dewatering was impractical or not feasible. The project involved the use of temporary flow diversions, cofferdams, and silt curtains to minimize contaminant migration and prevent exposure to biota during excavation. The work was performed during summer and fall months to avoid critical fish life cycles, migratory periods, and dangerous high flow conditions. Mussel and fish relocation were conducted to reduce exposures in work areas. A barge-mounted excavator with a special environmental bucket was used to dredge in the river. Dry excavation was done with standard equipment. The excavated material was placed into containers on floats, transported to the shoreline, lifted out of the river, placed onto a staging pad, dewatered, then loaded and transported to an off-site treatment facility. Contaminated remedial wastewater, drained from the dredge spoils, was collected in fractionation tanks and treated to meet criteria established in a permit issued by the Holyoke Department of Public Works. The treated wastewater was then discharged into the main city sewer interceptor line and sent directly to the water pollution control facility.

Prompted by MassDEP's observation of unmapped tar deposits in 2005, HWP was required to conduct a more intensive survey for tar in 2006. Information obtained during remediation and diver surveys, confirmed that the extent of tar deposits was much greater than initial estimates. The tar deposits were originally thought to occupy less than 2 acres, but the new estimate is around 30 acres. Because of the larger volume and associated cost for removal, HWP proposed to complete a comprehensive ecological and human health risk characterization to guide in risk management and remediation planning rather than to continue with removal under the presumption of harm to biota.

An important aspect of the site, now being scrutinized, is the hardness due to weathering of some tar deposits. Studies and risk assessment tools are proposed to determine if the more weathered tar has undergone changes that render it less toxic and mobile than the softer tar deposits, and therefore, whether it poses less or no significant risk of harm to biota.

MassDEP is currently reviewing the revised risk characterization Scope of Work, which has been developed to investigate if any substantial hazard has been mitigated by the remediation conducted to date and weathering processes that have reduced the mobility and toxicity of the tar.

Former Holyoke Gas Works (Land Site) RTN 1-816

Coal tar and water gas tar are the most widespread contaminants at the two sites. Ten million gallons of tar were produced over the life of the plant and much of the tar was released into the environment. The properties of tar make the assessment and remediation very complex and technically challenging. Coal tar is a dense non-aqueous phase liquid (DNAPL) whereas CWG tar reportedly has a density nearly equivalent to water. Over time tar fractionates into light non-aqueous phase liquid (LNAPL) and DNAPL. Constituents of tar also dissolve more readily into groundwater when comingled with gas oil. Fate and transport of tar is complicated since the LNAPL and dissolved LNAPL move with groundwater while DNAPL sinks and flows along the underlying bedrock and seeps into bedrock fractures. Recovery of NAPL tar is necessary, expensive, and expected to take 10 to 20 years. Listed below are summarized findings, tasks, and plans pertaining to the Gas Works site:

- 8 acres, industrial /commercial area with residential areas 0.25 miles from site
- Oil / tar breaking out in the Tailrace first observed and reported to MassDEP in 1990
- Sources removed in 1994 to 1995 include 3 underground storage tanks, 2 aboveground storage tanks, 3 tar wells, 1000 yd³ soil, & 100,000 gal. of tar / oil / water mix were recovered and recycled
- Gas oil and fuel oil (LNAPLs), and tar (DNAPL) observed to be migrating > 700 feet from sources; contaminants in groundwater & bedrock as seen in monitoring wells and soil borings
- Quarterly groundwater gauging program initiated in March 2001
- Weekly tar thickness gauging and tar bailing program initiated in November 2001
- Two pilot-scale NAPL recovery systems installed in 2003: no heat system along Tailrace; thermally-enhanced (steam sparge) on property near former east tar well
- In 2004, approximately 8000 tons of tar-impacted soil were removed from 2 gasholders and a tar separator, treated via on-site solidification & stabilization using addition of Portland cement (8%) and liquid asphalt (8 gallons per ton), and the end product was re-used as backfill in the gasholders
- Re-evaluation of arsenic and residual tar impacts in soil concluded no significant future health risk as long as site use is restricted to non-residential activities
- Removal and off-site disposal of approximately 1000 tons of tar solids and soil near valves along northern floodwall: accessible soil excavated & disposed off-site in 2005.
- Both NAPL recovery systems were upgraded to full scale between August 2006 and April 2007: installed cost of \$750 K with estimated annual operational cost of \$140 K
 - Steam-enhanced system has 7 sparge points and 7 recovery wells

- Tailrace collection is non-thermal and uses 21 overburden recovery wells and 4 bedrock recovery wells; spacing is at 10-foot intervals.
- Future Remedies-
 - 2009 Raceway: In-situ Capping & Heated Recovery Well Installation
 - 2010 Tailrace: Bulkhead Installation and/or Embankment Capping